Área Departamental de Engenharia da Eletrónica e Telecomunicações e de Computadores (ADEETC)

LEIC

Trabalho prático 2

OSPF

Redes de Internet

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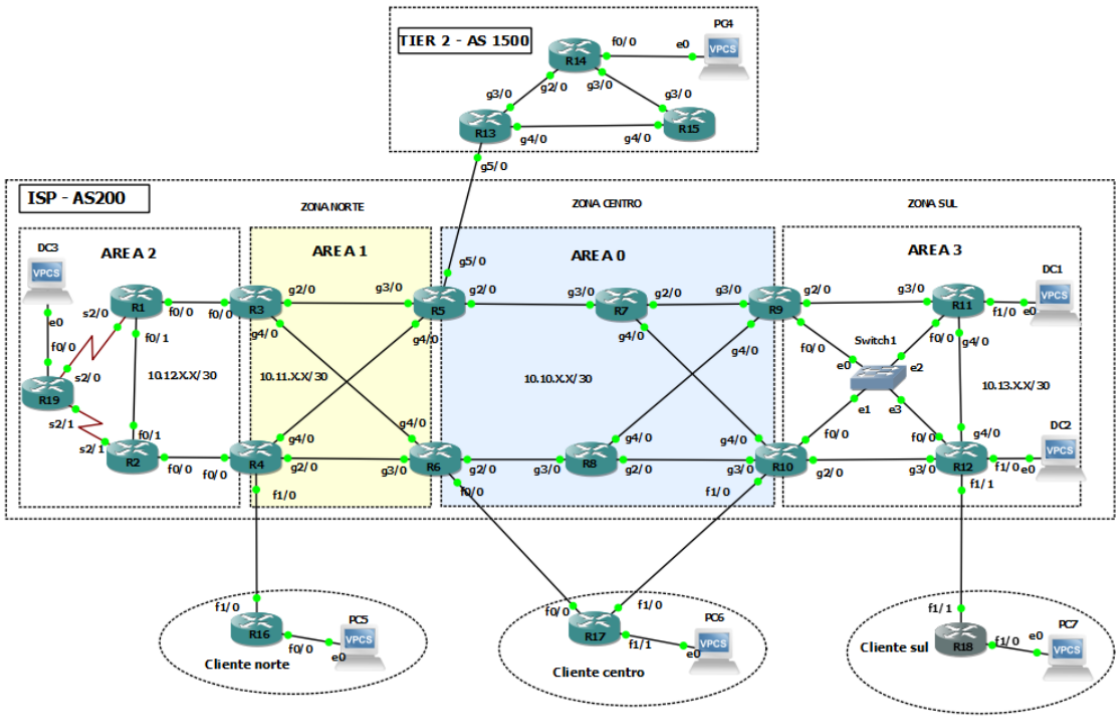
Índice

Introdução

- Este trabalho tem como objetivo o aprofundamento dos conhecimentos sobre o protocolo OSPF.

- A topologia objeto de estudo corresponde à rede de uma operadora com 12 POPs (*Points-of-Presence*) distribuídos por todo o território nacional. A rede é constituída por ligações dedicadas de alto débito, entre os routers, suportadas na sua infraestrutura ótica de transmissão DWDM. Na zona sul por razões de futuros Upgrading os routersestão adicionalmente interligados através de um LAN (switch1). A operadora é um ISP que fornece conetividade a várias empresas e trânsito por um ISP maior de Tier 2. A empresa possui três DC (Data Centers 1 a 3) para prestar serviços de *Web Hosting* e *Cloud Services*. O DC3 instalado numa zona remota, por falta de rede DWDM está ligado diretamente aos POP da zona norte.

Topologia do trabalho



Endereçamento

Grupo 9, 9*4 = 36

O ISP recorreu ao RIPE para conseguir as seguintes redes :

- ASN200
- 30.36.0.0/14
- 40.9.0.0/20

Na rede interna utiliza endereços privados. O ISP de Tier 2 possui o seguinte endereçamento: 50.0.0.0/22

Clientes: 30.36.0.0/14; interligação 40.9.0.0/16

- Centro: primeira /16 de 30.36.0.0/14 e segunda /24 de 40.9.0.0/20
- Norte: segunda /16 de 30.36.0.0/14 e primeira /24 de 40.9.0.0/20
- Sul: terceira /16 de 30.36.0.0/14 e terceira /24 de 40.9.0.0/20
- ISP: quarta /16 de 30.36.0.0/14

Cliente_centro: 30.36.0.0/22 – 4 redes /24, 1 rede ligada e 3 redes simuladas
Cliente_norte: 30.37.0.0/22
Cliente_sul: 30.38.0.0/22 – 4 redes /26, 1 rede ligada e 3 redes simuladas

DC1: 30.39.1.0/24
DC2: 30.39.2.0/24
DC3: 30.39.3.0/24

Nas ligações /30 entre os routers, o primeiro endereço é atribuído ao router de número mais baixo.

Nas redes com DC ou PC, os routers possuem o último endereço IP e os DC ou PC o primeiro.

Rede *core* OSPF do ISP

Loopbacks

- Routers: 10.255."nºRouter"."nºRouter"

PTP

- Regra geral: 10."area"."nºRouter+baixo""nºRouter+alto".X/30

  Exceto nas seguintes ligações em que terão o terceiro byte do endereço IP será:

  - R9-R11: 119
  - R10-R11: 110
  - R10-R12: 120
  - R11-R12: 121

Rede do switch1:

10.13.74.0/27 (R9=.1, R10=.2, R11=.3 e R12=.4)

Redes Interligação

- ISP-Cliente norte: 1ª /30 da primeira /24 pertencente à 40.9.0.0/20
- ISP-Cliente centro: 4ª e 5ª/30 da segunda /24 pertencente à 40.9.0.0/20
- ISP-Cliente sul: 5ª /30 da terceira /24 pertencente à 40.9.0.0/20

ISP Tier 2(ASN1500)

- PTP no core OSPF: 1ª, 2ª e 3ª /30 do endereçamento do ISP Tier 2.
- Resto do Mundo é simulado no PC4 com a rede 8.8.0.0/16, possuindo o PC4 o primeiro endereço.
- R13-R5: penúltima /30 da 1ª /24 do endereçamento do ISP Tier 2

Tarefas

1. Configuração dos routers e DC(PC) do ISP

a)

Nesta fase não foram configuradas as interfaces dos routers destinadas às redes de interligação aos clientes e Tier de nível 2.

b)

A configuração OSPF da rede do ISP deverá ter em atenção os seguintes pontos:

- Processo OSPF identificado com o número 1
- O router ID deve ser configurado manualmente e poder vir a ser injetado em todo o OSPF do ISP. Não faça, no entanto, a injeção dos respetivos Loopback para não sobrecarregar as tabelas de encaminhamentodos routers;
- Nos *links* onde não é expectável vizinhos OSPF, não devem ser enviados Hellos
- O custo OSPF deve ter em conta o facto de existirem interfaces Gigabit
- Os routers dos *Data Centers* são *routers* interiores das respetivas áreas
- As áreas 2 e 3 estão ligadas à área de *backbone*, nesta fase, sem qualquer filtragem dos LSA.

c)

Foram configurados os endereços de IP de cada Data Center (PC). Para isto foi utilizado o comando ip [endereço]/[netmask] [gateway address].

```
DC1> ip 30.39.1.1/24 30.39.1.2
Checking for duplicate address...
PC1 : 30.39.1.1 255.255.255.0 gateway 30.39.1.2

DC1> sh ip

NAME        : DC1[1]
IP/MASK     : 30.39.1.1/24
GATEWAY     : 30.39.1.2
DNS         :
MAC         : 00:50:79:66:68:00
LPORT       : 10202
RHOST:PORT  : 127.0.0.1:10203
MTU:        : 1500
```

Figura 2 - Configuração DC1

```
DC2> ip 30.39.2.1/24 30.39.2.2
Checking for duplicate address...
PC1 : 30.39.2.1 255.255.255.0 gateway 30.39.2.2

DC2> sh ip

NAME        : DC2[1]
IP/MASK     : 30.39.2.1/24
GATEWAY     : 30.39.2.2
DNS         :
MAC         : 00:50:79:66:68:01
LPORT       : 10200
RHOST:PORT  : 127.0.0.1:10201
MTU:        : 1500
```

Figura 1 - Configuração DC2

```
DC3> ip 30.39.3.1/24 30.39.3.2
Checking for duplicate address...
PC1 : 30.39.3.1 255.255.255.0 gateway 30.39.3.2

DC3> sh ip

NAME        : DC3[1]
IP/MASK     : 30.39.3.1/24
GATEWAY     : 30.39.3.2
DNS         :
MAC         : 00:50:79:66:68:02
LPORT       : 10206
RHOST:PORT  : 127.0.0.1:10207
MTU:        : 1500
```

Figura 3 - Configuração DC3

d)

Os routers do *backbone*, também conhecido como a área 0, são os routers R5, R6, R7, R8, R9 e R10. Para configurar estes routers foram dadas às interfaces os seus endereços de acordo com as regras do enunciado. Também foi necessário configurar o OSPF em cada router para ser possível estabelecer adjacências.

O comando network permite que o endereço de IP indicado seja anunciado no OSPF.

```
R5(config)#router ospf 1
R5(config-router)#passive-interface default
R5(config-router)#no passive-interface g2/0
R5(config-router)#no passive-interface g3/0
R5(config-router)#no passive-interface g4/0
R5(config-router)#no passive-interface g5/0
R5(config-router)#
R5(config-router)#network 10.10.57.0 0.0.0.3 area 0
R5(config-router)#network 10.10.57.0 0.0.0.3 area 1
*Dec 29 19:49:36.539: %OSPF-5-ADJCHG: Process 1, Nbr
R5(config-router)#network 10.11.35.0 0.0.0.3 area 1
R5(config-router)#network 10.11.45.0 0.0.0.3 area 1
```

Figura 4 – Distribuição de rotas OSPF

O comando router ospf 1 indica que o processo OSPF é identificado pelo número 1. O router ID foi configurado com o número do router em questão.

```
R5#config t
Enter configuration commands, one per line.  End wit
R5(config)#router ospf 1
R5(config-router)#router-id 5.5.5.5
R5(config-router)#ex
R5(config)#int lo0
R5(config-if)#ip address 10.255.5.5 255.255.255.255
R5(config-if)#ex
R5(config)#int g2/0
R5(config-if)#ip address 10.10.57.1 255.255.255.252
R5(config-if)#ex
R5(config)#int g3/0
R5(config-if)#ip address 10.11.35.2 255.255.255.252
R5(config-if)#ex
R5(config)#int g4/0
R5(config-if)#ip address 10.11.45.2 255.255.255.252
R5(config-if)#int g5/0
R5(config-if)#ip address 50.0.0.2 255.255.255.252
```

Figura 5 - Configuração das interfaces

Os restantes routers foram configurados do mesmo modo. Cada router ID tem o valor do seu número de router.

```
R6#config t
Enter configuration commands, one per line.  End wit
R6(config)#router ospf 1
R6(config-router)#router-id 6.6.6.6
R6(config-router)#ex
R6(config)#int lo0
R6(config-if)#ip address 10.255.6.6 255.255.255.255
R6(config-if)#ex
R6(config)#int g2/0
R6(config-if)#ip address 10.10.68.1 255.255.255.252
R6(config-if)#ex
R6(config)#int g3/0
R6(config-if)#ip address 10.11.46.2 255.255.255.252
R6(config-if)#ex
R6(config)#int g4/0
R6(config-if)#ip address 10.11.36.2 255.255.255.252
R6(config-if)#ex
R6(config)#router ospf 1
R6(config-router)#passive-interface default
R6(config-router)#no passive-interface g2/0
R6(config-router)#no passive-interface g3/0
R6(config-router)#no passive-interface g4/0
R6(config-router)#
R6(config-router)#network 10.10.68.0 0.0.0.3 area 0
R6(config-router)#network 10.10.6.0 0.0.0.3 area 0
*Dec 29 19:48:27.355: %OSPF-5-ADJCHG: Process 1, Nbr
R6(config-router)#network 10.11.46.0 0.0.0.3 area 1
R6(config-router)#network 10.11.36.0 0.0.0.3 area 1
R6(config-router)#ex
R6(config)#int f0/0
R6(config-if)#ip address 40.9.1.1 255.255.255.252
```

Figura 6 - Configuração R6

```
R7(config)#router ospf 1
R7(config-router)#router-id 7.7.7.7
R7(config-router)#ex
R7(config)#int lo0
R7(config-if)#ip address 10.255.7.7 255.255.255.255
R7(config-if)#ex
R7(config)#int g2/0
R7(config-if)#ip address 10.10.79.1 255.255.255.252
R7(config-if)#ex
R7(config)#int g3/0
R7(config-if)#ip address 10.10.57.2 255.255.255.252
R7(config-if)#ex
R7(config)#int g4/0
R7(config-if)#ip address 10.10.107.1 255.255.255.252
R7(config-if)#ex
R7(config)#router ospf 1
R7(config-router)#passive-interface default
R7(config-router)#no passive-interface g2/0
R7(config-router)#no passive-interface g3/0
R7(config-router)#no passive-interface g4/0
R7(config-router)#
R7(config-router)#network 10.10.79.0 0.0.0.3 area 0
R7(config-router)#network 10.10.57.0 0.0.0.3 area 0
R7(config-router)#network 10.10.107.0 0.0.0.3 area 0
```

Figura 7 - Configuração R7

```
R8#config t
Enter configuration commands, one per line.  End with CNTL/Z.
R8(config)#router ospf 1
R8(config-router)#router-id 8.8.8.8
R8(config-router)#ex
R8(config)#int lo0
R8(config-if)#ip address 10.255.8.8 255.255.255.255
R8(config-if)#ex
R8(config)#int g2/0
R8(config-if)#ip address 10.10.108.1 255.255.255.252
R8(config-if)#ex
R8(config)#int g3/0
R8(config-if)#ip address 10.10.68.2 255.255.255.252
R8(config-if)#ex
R8(config)#int g4/0
R8(config-if)#ip address 10.10.89.1 255.255.255.252
R8(config-if)#ex
R8(config)#router ospf 1
R8(config-router)#passive-interface default
R8(config-router)#no passive-interface g2/0
R8(config-router)#no passive-interface g3/0
R8(config-router)#no passive-interface g4/0
R8(config-router)#
R8(config-router)#network 10.10.108.0 0.0.0.3 area 0
R8(config-router)#network 10.10.68.0 0.0.0.3 area 0
R8(config-router)#network 10.10.89.0 0.0.0.3 area 0
```

Figura 8 - Configuração R8

```
R9#config t
Enter configuration commands, one per line.  End with CNTL/Z.
R9(config)#router ospf 1
R9(config-router)#router-id 9.9.9.9
R9(config-router)#ex
R9(config)#int lo0
R9(config-if)#ip address 10.255.9.9 255.255.255.255
R9(config-if)#ex
R9(config)#int g2/0
R9(config-if)#ip address 10.13.119.1 255.255.255.252
R9(config-if)#ex
R9(config)#int g3/0
R9(config-if)#ip address 10.10.79.2 255.255.255.252
R9(config-if)#ex
R9(config)#int g4/0
R9(config-if)#ip address 10.10.89.2 255.255.255.252
R9(config-if)#ex
R9(config)#int f0/0
R9(config-if)#ip address 10.13.74.1 255.255.255.224
R9(config-if)#ex
R9(config)#router ospf 1
R9(config-router)#passive-interface default
R9(config-router)#no passive-interface f0/0
R9(config-router)#no passive-interface g2/0
R9(config-router)#no passive-interface g3/0
R9(config-router)#no passive-interface g4/0
R9(config-router)#
R9(config-router)#network 10.13.74.0 0.0.0.31 area 3
R9(config-router)#network 10.13.119.0 0.0.0.3 area 3
R9(config-router)#network 10.10.79.0 0.0.0.3 area 0
R9(config-router)#network 10.10.89.0 0.0.0.3 area 0
*Dec 29 19:46:28.739: %OSPF-5-ADJCHG: Process 1, Nbr 7.7.7.7
R9(config-router)#network 10.10.89.0 0.0.0.3 area 0
```

Figura 9 - Configuração R9

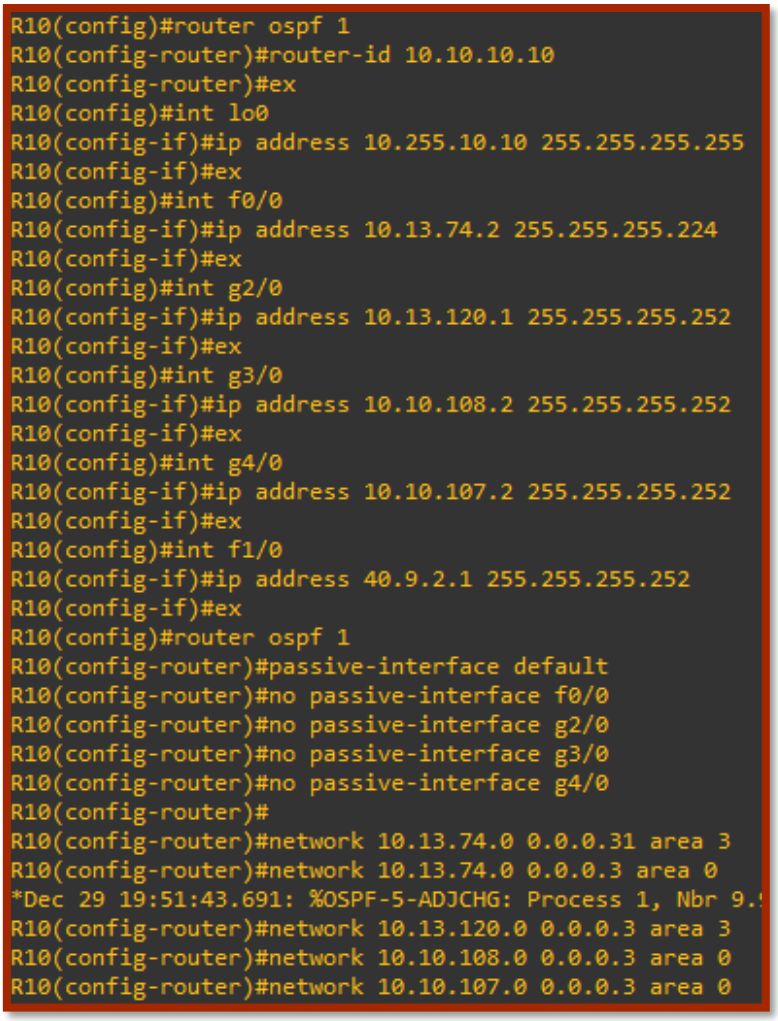


Figura 10 - Configuração R10

As instruções **passive-interface default** não deixam passar hello packets em nenhuma interface, o comando **no passive-interface [interface]** habilita a passagem desses hello packets para as interfaces apenas necessárias.

e)

```
R7#show ip route
Codes: C - connected, S - static, R - RIP, M - mobile, B - BGP
       D - EIGRP, EX - EIGRP external, O - OSPF, IA - OSPF inter area
       N1 - OSPF NSSA external type 1, N2 - OSPF NSSA external type 2
       E1 - OSPF external type 1, E2 - OSPF external type 2
       i - IS-IS, su - IS-IS summary, L1 - IS-IS level-1, L2 - IS-IS level-2
       ia - IS-IS inter area, * - candidate default, U - per-user static route
       o - ODR, P - periodic downloaded static route

Gateway of last resort is not set

     10.0.0.0/8 is variably subnetted, 14 subnets, 3 masks
O IA    10.10.35.0/30 [110/2] via 10.10.57.1, 00:04:56, GigabitEthernet3/0
O IA    10.10.36.0/30 [110/4] via 10.10.107.2, 00:04:56, GigabitEthernet4/0
                      [110/4] via 10.10.79.2, 00:04:56, GigabitEthernet2/0
O IA    10.10.45.0/30 [110/2] via 10.10.57.1, 00:04:56, GigabitEthernet3/0
O IA    10.10.46.0/30 [110/4] via 10.10.107.2, 00:04:56, GigabitEthernet4/0
                      [110/4] via 10.10.79.2, 00:04:56, GigabitEthernet2/0
C       10.10.57.0/30 is directly connected, GigabitEthernet3/0
O       10.10.68.0/30 [110/3] via 10.10.107.2, 00:04:56, GigabitEthernet4/0
                      [110/3] via 10.10.79.2, 00:04:56, GigabitEthernet2/0
O IA    10.13.74.0/27 [110/2] via 10.10.107.2, 00:04:56, GigabitEthernet4/0
                      [110/2] via 10.10.79.2, 00:04:56, GigabitEthernet2/0
C       10.10.79.0/30 is directly connected, GigabitEthernet2/0
O       10.10.89.0/30 [110/2] via 10.10.79.2, 00:04:57, GigabitEthernet2/0
C       10.10.107.0/30 is directly connected, GigabitEthernet4/0
O       10.10.108.0/30 [110/2] via 10.10.107.2, 00:04:58, GigabitEthernet4/0
O IA    10.10.119.0/30 [110/2] via 10.10.79.2, 00:04:58, GigabitEthernet2/0
O IA    10.10.120.0/30 [110/2] via 10.10.107.2, 00:04:58, GigabitEthernet4/0
C       10.255.7.7/32 is directly connected, Loopback0
```

O comando **show ip route** mostra todas as rotas que o router R7 apresenta na sua tabela de encaminhamento. Os endereços com o código C indicam que estão diretamente ligados, e são os endereços das interfaces dos routers que se encontram ligados ao router em questão. As outras rotas fazem parte do OSPF e conseguem ser acedidas através de outros caminhos.

Na base de dados OSPF encontram-se LSAs de tipo 1,2 e 3. Sendo o de tipo 1, tipo Router LSA e são os que se encontram na mesma área de origem. Os pacotes de LSA Type 1 (Router LSA) são enviados entre routers dentro da mesma área de origem e não saiem dessa área.

De tipo 2, tipo Network LSA. Os pacotes de LSA Type 2 (Network LSA) são gerados pelo DR (designated router) para descrever todos os routers ligados a este segmento diretamente. Este tipo de pacotes são flooded entre os vizinhos da mesma área de origem.

Os pacotes de LSA Type 3 (Summary LSA) são gerados pelos ABR (Area Border Router) para sumarizar a área e anunciar informação de routers inter-area para outras áreas que estão ligadas ao ABR.

```
R7#show ip ospf database

           OSPF Router with ID (7.7.7.7) (Process ID 1)

               Router Link States (Area 0)

Link ID         ADV Router      Age         Seq#       Checksum Link count
5.5.5.5         5.5.5.5         1080        0x80000003 0x00F772 1
6.6.6.6         6.6.6.6         839         0x80000003 0x009EAD 1
7.7.7.7         7.7.7.7         389         0x80000006 0x00E686 3
8.8.8.8         8.8.8.8         391         0x80000006 0x00FE3A 3
9.9.9.9         9.9.9.9         1500        0x80000004 0x00E747 2
10.10.10.10     10.10.10.10     373         0x80000005 0x006265 2

               Net Link States (Area 0)

Link ID         ADV Router      Age         Seq#       Checksum
10.10.57.2      7.7.7.7         1086        0x80000001 0x002081
10.10.68.2      8.8.8.8         847         0x80000001 0x00DCAD
10.10.79.1      7.7.7.7         1514        0x80000001 0x00FF7C
10.10.89.1      8.8.8.8         1501        0x80000001 0x0095D4
10.10.107.1     7.7.7.7         389         0x80000001 0x00FC5F
10.10.108.1     8.8.8.8         391         0x80000001 0x00F55D

               Summary Net Link States (Area 0)

Link ID         ADV Router      Age         Seq#       Checksum
10.10.35.0      5.5.5.5         1075        0x80000001 0x006D86
10.10.36.0      6.6.6.6         825         0x80000001 0x0044AA
10.10.45.0      5.5.5.5         1067        0x80000001 0x00FEEA
10.10.46.0      6.6.6.6         835         0x80000001 0x00D50F
10.10.119.0     9.9.9.9         1526        0x80000001 0x00553A
10.10.119.0     10.10.10.10     410         0x80000001 0x004149
10.10.120.0     9.9.9.9         369         0x80000001 0x005439
10.10.120.0     10.10.10.10     370         0x80000001 0x002C5E
10.13.74.0      9.9.9.9         1526        0x80000001 0x00795C
10.13.74.0      10.10.10.10     410         0x80000001 0x005B76
```

Figura 11 - Base de dados OSPF de R7

f)

O OSPF faz balanceamento de carga.

```
R5#traceroute 10.10.68.2

Type escape sequence to abort.
Tracing the route to 10.10.68.2

  1 10.10.57.2 16 msec 32 msec 16 msec
  2 10.10.107.2 72 msec 60 msec 4 msec
  3 10.10.108.1 92 msec 16 msec 112 msec
```

Figura 12 - Comando traceroute

g)

Por default a métrica de uma interface de 1Gbps e de 10Gbps é 1.

```
R3#config t
Enter configuration commands, one per line.  End wit
R3(config)#router ospf 1
R3(config-router)#router-id 3.3.3.3
R3(config-router)#ex
R3(config)#int lo0
R3(config-if)#ip address 10.255.3.3 255.255.255.255
R3(config-if)#ex
R3(config)#int f0/0
R3(config-if)#ip address 10.12.13.2 255.255.255.252
R3(config-if)#ex
R3(config)#int g2/0
R3(config-if)#ip address 10.11.35.1 255.255.255.252
R3(config-if)#ex
R3(config)#int g4/0
R3(config-if)#ip address 10.11.36.1 255.255.255.252
R3(config-if)#ex
R3(config)#router ospf 1
R3(config-router)#passive-interface default
R3(config-router)#no passive-interface f0/0
R3(config-router)#no passive-interface g2/0
R3(config-router)#no passive-interface g4/0
R3(config-router)#
R3(config-router)#network 10.12.13.0 0.0.0.3 area 2
R3(config-router)#network 10.11.35.0 0.0.0.3 area 1
R3(config-router)#network 10.11.36.0 0.0.0.3 area 1
```

Figura 13 - Configuração R3

```
R4#config t
Enter configuration commands, one per line.  End wit
R4(config)#router ospf 1
R4(config-router)#router-id 4.4.4.4
R4(config-router)#ex
R4(config)#int lo0
R4(config-if)#ip address 10.255.4.4 255.255.255.255
R4(config-if)#ex
R4(config)#int f1/0
R4(config-if)#ip address 40.9.0.1 255.255.255.252
R4(config-if)#ex
R4(config)#int g2/0
R4(config-if)#ip address 10.11.46.1 255.255.255.252
R4(config-if)#ex
R4(config)#int f0/0
R4(config-if)#ip address 10.12.24.2 255.255.255.252
R4(config-if)#ex
R4(config)#int g4/0
R4(config-if)#ip address 10.11.45.1 255.255.255.252
R4(config-if)#ex
R4(config)#router ospf 1
R4(config-router)#passive-interface default
R4(config-router)#no passive-interface f0/0
R4(config-router)#no passive-interface g2/0
R4(config-router)#no passive-interface g4/0
R4(config-router)#no passive-interface f1/0
R4(config-router)#
R4(config-router)#network 10.11.46.0 0.0.0.3 area 1
R4(config-router)#network 10.11.45.0 0.0.0.3 area 1
R4(config-router)#network 10.12.24.0 0.0.0.3 area 2
```

Figura 14 - Configuração R4

Os outros routers, R5 e R6, já foram configurados anteriormente na alínea d).

Todas as áreas têm que estar ligadas ao backbone (área 0) caso haja alguma falha. Para isso, foi necessário criar uma ligação virtual entre a área 1 e a área 0. Ligar o ABR da área 0 com o ABR da área 1.

Entre o router R3 e o router R5 – area 1 virtual-link 5.5.5.5
Entre o router R5 e o router R3 – area 1 virtual-link 3.3.3.3
Entre o router R4 e o router R6 – area 1 virtual-link 6.6.6.6
Entre o router R6 e o router R4 – area 1 virtual-link 4.4.4.4

h)

Não existem alterações na tabela de encaminhamento e na base de dados OSPF.

i)

Os routers da **área 2**, routers R1, R2 e R19, foram configurados do mesmo modo que os anteriormente configurados. Abaixo são apresentadas as configurações desses routers.

```
R1#config t
Enter configuration commands, one per line.  End with
R1(config)#router ospf 1
R1(config-router)#router-id 1.1.1.1
R1(config-router)#ex
R1(config)#int lo0
R1(config-if)#ip address 10.255.1.1 255.255.255.255
R1(config-if)#ex
R1(config)#int f0/0
R1(config-if)#ip address 10.12.13.1 255.255.255.252
R1(config-if)#ex
R1(config)#int f0/1
R1(config-if)#ip address 10.12.12.1 255.255.255.252
R1(config-if)#ex
R1(config)#int s2/0
R1(config-if)#ip address 10.12.119.1 255.255.255.252
R1(config-if)#ex
R1(config)#router ospf 1
R1(config-router)#passive-interface default
R1(config-router)#no passive-interface f0/0
R1(config-router)#no passive-interface f0/1
R1(config-router)#no passive-interface s2/0
R1(config-router)#
R1(config-router)#network 10.12.13.0 0.0.0.3 area 2
R1(config-router)#network 10.12.12.0 0.0.0.3 area 2
R1(config-router)#network 10.12.119.0 0.0.0.3 area 2
```

Figura 15 - Configuração R1

Foi realizado o comando [area-id] virtual-link [router-id] para ligar a área 2 ao backbone. Para isso é necessário ligar a área 2 à área 1 que contém uma ligação ao backbone. O router R19 contém um link virtual com o router R2 para estar conectado ao backbone (área 0).

```
R2#config t
Enter configuration commands, one per line.  End with
R2(config)#router ospf 1
R2(config-router)#router-id 2.2.2.2
R2(config-router)#ex
R2(config)#int lo0
R2(config-if)#ip address 10.255.2.2 255.255.255.255
R2(config-if)#ex
R2(config)#int f0/0
R2(config-if)#ip address 10.12.24.1 255.255.255.252
R2(config-if)#ex
R2(config)#int f0/1
R2(config-if)#ip address 10.12.12.2 255.255.255.252
R2(config-if)#ex
R2(config)#int s2/1
R2(config-if)#ip address 10.12.219.1 255.255.255.252
R2(config-if)#ex
R2(config)#router ospf 1
R2(config-router)#passive-interface default
R2(config-router)#no passive-interface f0/0
R2(config-router)#no passive-interface f0/1
R2(config-router)#no passive-interface s2/1
R2(config-router)#
R2(config-router)#network 10.12.24.0 0.0.0.3 area 2
R2(config-router)#network 10.12.12.0 0.0.0.3 area 2
R2(config-router)#network 10.12.219.0 0.0.0.3 area 2
```

Figura 16 - Configuração R2

```
R19#config t
Enter configuration commands, one per line.  End with C
R19(config)#router ospf 1
R19(config-router)#router-id 19.19.19.19
R19(config-router)#ex
R19(config)#int lo0
R19(config-if)#ip address 10.255.19.19 255.255.255.255
R19(config-if)#ex
R19(config)#int s2/0
R19(config-if)#ip address 10.12.119.2 255.255.255.252
R19(config-if)#ex
R19(config)#int s2/1
R19(config-if)#ip address 10.12.219.2 255.255.255.252
R19(config-if)#ex
R19(config)#int f0/0
R19(config-if)#ip address 30.39.3.2 255.255.255.252
R19(config-if)#ex
R19(config)#router ospf 1
R19(config-router)#passive-interface default
R19(config-router)#no passive-interface s2/0
R19(config-router)#no passive-interface s2/1
R19(config-router)#no passive-interface f0/0
R19(config-router)#
R19(config-router)#network 10.12.119.0 0.0.0.3 area 2
R19(config-router)#network 10.12.119.0 0.0.0.3 area 2
*Mar  1 00:30:57.567: %OSPF-5-ADJCHG: Process 1, Nbr 1.
R19(config-router)#network 10.12.219.0 0.0.0.3 area 2
R19(config-router)#
*Mar  1 00:31:09.471: %OSPF-5-ADJCHG: Process 1, Nbr 2.
R19(config-router)#network 30.39.3.0 0.0.0.3 area 2
```

Figura 17 - Configuração R19

Os routers da **área 3**, routers R11 e R12, foram configurados do mesmo modo que os outros. As interfaces foram identificados com os seus endereços de IP de acordo com o seu número de router, exceto os routers ligados aos Data Centers que terão uma regra diferente para o seu IP address.

```
R11(config)#router ospf 1
R11(config-router)#router-id 11.11.11.11
R11(config-router)#ex
R11(config)#int f1/0
R11(config-if)#ip address 30.39.1.2 255.255.255.252
R11(config-if)#ex
R11(config)#int g3/0
R11(config-if)#ip address 10.13.119.2 255.255.255.252
R11(config-if)#ex
R11(config)#int f0/0
R11(config-if)#ip address 10.13.74.3 255.255.255.224
R11(config-if)#ex
R11(config)#int g4/0
R11(config-if)#ip address 10.13.121.1 255.255.255.252
R11(config-if)#ex
R11(config)#router ospf 1
R11(config-router)#passive-interface default
R11(config-router)#no passive-interface f0/0
R11(config-router)#no passive-interface f1/0
R11(config-router)#no passive-interface g3/0
R11(config-router)#no passive-interface g4/0
R11(config-router)#
R11(config-router)#network 30.39.1.0 0.0.0.3 area 3
R11(config-router)#network 10.13.120.0 0.0.0.3 area 3
R11(config-router)#network 10.13.121.0 0.0.0.3 area 3
R11(config-router)#network 10.13.74.0 0.0.0.31 area 3
```

Figura 18 - Configuração R11

```
R12(config)#router ospf 1
R12(config-router)#router-id 12.12.12.12
R12(config-router)#ex
R12(config)#int f1/0
R12(config-if)#ip address 30.39.2.2 255.255.255.252
R12(config-if)#ex
R12(config)#int g3/0
R12(config-if)#ip address 10.13.120.2 255.255.255.252
R12(config-if)#ex
R12(config)#int g4/0
R12(config-if)#ip address 10.13.121.2 255.255.255.252
R12(config-if)#ex
R12(config)#int f0/0
R12(config-if)#ip address 10.13.74.4 255.255.255.224
R12(config-if)#ex
R12(config)#int f1/1
R12(config-if)#ip address 40.9.3.1 255.255.255.252
R12(config-if)#ex
R12(config)#router ospf 1
R12(config-router)#passive-interface default
R12(config-router)#no passive-interface f0/0
R12(config-router)#no passive-interface f1/0
R12(config-router)#no passive-interface f1/1
R12(config-router)#no passive-interface g3/0
R12(config-router)#no passive-interface g4/0
R12(config-router)#
R12(config-router)#network 30.39.2.0 0.0.0.3 area 3
R12(config-router)#network 10.13.120.0 0.0.0.3 area 3
R12(config-router)#network 10.13.121.0 0.0.0.3 area 3
R12(config-router)#network 10.13.74.0 0.0.0.31 area 3
```

Figura 19 - Configuração R12

Foi necessário configurar o virtual-link entre R11-R9 e R12-R10.

```
R9(config)#router ospf 1
R9(config-router)#area 3 virtual-
*Dec 29 22:28:57.023: %OSPF-4-ERRRCV: Received inv
 not found from 10.13.74.3, FastEthernet0/0
R9(config-router)#area 3 virtual-link 11.11.11.11
```

```
R11(config)#router ospf 1
R11(config-router)#area 3 virtual-link 9.9.9.9
```

```
R10(config)#router ospf 1
R10(config-router)#area 3 virtual-link 12.12.1
*Dec 29 22:12:02.215: %OSPF-4-ERRRCV: Received inva
 not found from 10.13.74.4, FastEthernet0/0
R10(config-router)#area 3 virtual-link 12.12.12.12
```

```
R12(config)#router ospf 1
R12(config-router)#area 3 virtual-link 10.10.10.10
```

Na tabela de encaminhamento do router R7 aparecem novos caminhos para os novos routers que foram configurados nas áreas circundantes, como também para os Data Centers 1 e 2.

```
     10.0.0.0/8 is variably subnetted, 16 subnets, 3 masks
O IA    10.10.35.0/30 [110/2] via 10.10.57.1, 00:00:38, GigabitEthernet3/0
O IA    10.10.36.0/30 [110/4] via 10.10.107.2, 00:00:38, GigabitEthernet4/0
                      [110/4] via 10.10.79.2, 00:00:38, GigabitEthernet2/0
O IA    10.10.45.0/30 [110/2] via 10.10.57.1, 00:00:38, GigabitEthernet3/0
O IA    10.10.46.0/30 [110/4] via 10.10.107.2, 00:00:38, GigabitEthernet4/0
                      [110/4] via 10.10.79.2, 00:00:38, GigabitEthernet2/0
C       10.10.57.0/30 is directly connected, GigabitEthernet3/0
O       10.10.68.0/30 [110/3] via 10.10.107.2, 00:00:38, GigabitEthernet4/0
                      [110/3] via 10.10.79.2, 00:00:38, GigabitEthernet2/0
O IA    10.13.74.0/27 [110/2] via 10.10.107.2, 00:00:38, GigabitEthernet4/0
                      [110/2] via 10.10.79.2, 00:00:38, GigabitEthernet2/0
C       10.10.79.0/30 is directly connected, GigabitEthernet2/0
O       10.10.89.0/30 [110/2] via 10.10.79.2, 00:00:39, GigabitEthernet2/0
C       10.10.107.0/30 is directly connected, GigabitEthernet4/0
O       10.10.108.0/30 [110/2] via 10.10.107.2, 00:00:40, GigabitEthernet4/0
O IA    10.13.112.0/30 [110/3] via 10.10.107.2, 00:00:40, GigabitEthernet4/0
                       [110/3] via 10.10.79.2, 00:00:40, GigabitEthernet2/0
O IA    10.10.119.0/30 [110/2] via 10.10.79.2, 00:00:40, GigabitEthernet2/0
O IA    10.10.120.0/30 [110/2] via 10.10.107.2, 00:00:40, GigabitEthernet4/0
O IA    10.13.120.0/30 [110/3] via 10.10.107.2, 00:00:40, GigabitEthernet4/0
                       [110/3] via 10.10.79.2, 00:00:40, GigabitEthernet2/0
C       10.255.7.7/32 is directly connected, Loopback0
     30.0.0.0/30 is subnetted, 2 subnets
O IA    30.39.1.0 [110/3] via 10.10.107.2, 00:00:41, GigabitEthernet4/0
                  [110/3] via 10.10.79.2, 00:00:41, GigabitEthernet2/0
O IA    30.39.2.0 [110/3] via 10.10.107.2, 00:00:41, GigabitEthernet4/0
                  [110/3] via 10.10.79.2, 00:00:41, GigabitEthernet2/0
```

Figura 20 - show ip route R7

Na base de dados OSPF do router R7 aumentou a quantidade de LSAs do tipo 3 devido aos ABRs anunciarem novas rotas.

```
R7#show ip ospf database

            OSPF Router with ID (7.7.7.7) (Process ID 1)

                Router Link States (Area 0)

Link ID         ADV Router      Age         Seq#       Checksum Link count
5.5.5.5         5.5.5.5         1476        0x80000007 0x00EF76 1
6.6.6.6         6.6.6.6         1309        0x80000007 0x0096B1 1
7.7.7.7         7.7.7.7         709         0x8000000A 0x00DE8A 3
8.8.8.8         8.8.8.8         683         0x8000000A 0x00F63E 3
9.9.9.9         9.9.9.9         119         0x80000009 0x00C4C4 3
10.10.10.10     10.10.10.10     357         0x8000000A 0x00DB41 3
11.11.11.11     11.11.11.11     2     (DNA) 0x80000002 0x00F15C 1
12.12.12.12     12.12.12.12     4     (DNA) 0x80000002 0x00D56B 1

                Net Link States (Area 0)

Link ID         ADV Router      Age         Seq#       Checksum
10.10.57.2      7.7.7.7         1464        0x80000005 0x001885
10.10.68.2      8.8.8.8         1198        0x80000005 0x00D4B1
10.10.79.1      7.7.7.7         1971        0x80000005 0x00F780
10.10.89.1      8.8.8.8         1950        0x80000005 0x008DD8
10.10.107.1     7.7.7.7         709         0x80000005 0x00F463
10.10.108.1     8.8.8.8         683         0x80000005 0x00ED61

                Summary Net Link States (Area 0)

Link ID         ADV Router      Age         Seq#       Checksum
10.10.35.0      5.5.5.5         1477        0x80000005 0x00658A
10.10.36.0      6.6.6.6         1311        0x80000005 0x003CAE
10.10.45.0      5.5.5.5         1477        0x80000005 0x00F6EE
10.10.46.0      6.6.6.6         1311        0x80000005 0x00CD13
10.10.119.0     9.9.9.9         1817        0x80000005 0x004D3E
10.10.119.0     10.10.10.10     676         0x80000005 0x00394D
10.10.119.0     11.11.11.11     78    (DNA) 0x80000001 0x002363
10.10.119.0     12.12.12.12     24    (DNA) 0x80000001 0x00057D
10.10.120.0     9.9.9.9         826         0x80000005 0x004C3D
10.10.120.0     10.10.10.10     677         0x80000005 0x002462
10.10.120.0     11.11.11.11     78    (DNA) 0x80000001 0x00186D
10.10.120.0     12.12.12.12     24    (DNA) 0x80000001 0x00F987
10.13.74.0      9.9.9.9         472         0x80000007 0x006D62
10.13.74.0      10.10.10.10     469         0x80000007 0x004F7C
10.13.74.0      11.11.11.11     78    (DNA) 0x80000001 0x003D90
10.13.74.0      12.12.12.12     24    (DNA) 0x80000001 0x001FAA
10.13.112.0     9.9.9.9         1017        0x80000001 0x00880A
10.13.112.0     10.10.10.10     1013        0x80000001 0x006A24
10.13.112.0     11.11.11.11     78    (DNA) 0x80000001 0x004249
10.13.112.0     12.12.12.12     24    (DNA) 0x80000001 0x002463
10.13.120.0     9.9.9.9         469         0x80000002 0x002E5B
10.13.120.0     10.10.10.10     465         0x80000002 0x001075
10.13.120.0     11.11.11.11     78    (DNA) 0x80000001 0x00F38E
10.13.120.0     12.12.12.12     24    (DNA) 0x80000001 0x00CBB3
30.39.1.0       9.9.9.9         1018        0x80000001 0x0014BF
30.39.1.0       10.10.10.10     1015        0x80000001 0x00F5D9
30.39.1.0       11.11.11.11     78    (DNA) 0x80000001 0x00CDFE
30.39.1.0       12.12.12.12     24    (DNA) 0x80000001 0x00B90E
30.39.2.0       9.9.9.9         470         0x80000002 0x0007CA
30.39.2.0       10.10.10.10     467         0x80000002 0x00E8E4
30.39.2.0       11.11.11.11     78    (DNA) 0x80000001 0x00CCFD
30.39.2.0       12.12.12.12     24    (DNA) 0x80000001 0x00A423
```

Figura 21 - Base de dados OSPF

j)

O comando tclsh permite ao router em questão fazer um ping para vários endereços diferentes num só comando. Abaixo é apresentado uma sugestão para o exercício pedido.

```
R7(tcl)#foreach address {
+>(tcl)#30.39.1.2
+>(tcl)#30.39.2.2
+>(tcl)#30.39.3.2
+>(tcl)#10.10.79.1
+>(tcl)#10.10.79.2
+>(tcl)#10.10.68.2
+>(tcl)#10.10.57.1
+>(tcl)#10.10.68.1
+>(tcl)#10.10.120.1
+>(tcl)#10.11.35.1
+>(tcl)#10.11.46.1
+>(tcl)#10.12.12.1
+>(tcl)#10.12.24.1
+>(tcl)#10.12.119.2
+>(tcl)#10.13.112.1
+>(tcl)#10.13.120.2
+>(tcl)#} { ping $address}
```

Figura 22 - Comando tclsh

```
Type escape sequence to abort.
Sending 5, 100-byte ICMP Echos to 30.39.1.2, timeout is 2 seconds:
!!!!!
Success rate is 100 percent (5/5), round-trip min/avg/max = 52/65/76 ms
Type escape sequence to abort.
Sending 5, 100-byte ICMP Echos to 30.39.2.2, timeout is 2 seconds:
!!!!!
Success rate is 100 percent (5/5), round-trip min/avg/max = 20/49/84 ms
Type escape sequence to abort.
Sending 5, 100-byte ICMP Echos to 30.39.3.2, timeout is 2 seconds:
!!!!!
Success rate is 100 percent (5/5), round-trip min/avg/max = 60/91/128 ms
Type escape sequence to abort.
Sending 5, 100-byte ICMP Echos to 10.10.79.1, timeout is 2 seconds:
!!!!!
Success rate is 100 percent (5/5), round-trip min/avg/max = 1/2/4 ms
Type escape sequence to abort.
Sending 5, 100-byte ICMP Echos to 10.10.79.2, timeout is 2 seconds:
!!!!!
Success rate is 100 percent (5/5), round-trip min/avg/max = 12/19/28 ms
Type escape sequence to abort.
Sending 5, 100-byte ICMP Echos to 10.10.68.2, timeout is 2 seconds:
!!!!!
Success rate is 100 percent (5/5), round-trip min/avg/max = 48/62/76 ms
Type escape sequence to abort.
Sending 5, 100-byte ICMP Echos to 10.10.57.1, timeout is 2 seconds:
!!!!!
Success rate is 100 percent (5/5), round-trip min/avg/max = 12/25/48 ms
Type escape sequence to abort.
Sending 5, 100-byte ICMP Echos to 10.10.68.1, timeout is 2 seconds:
!!!!!
Success rate is 100 percent (5/5), round-trip min/avg/max = 36/78/108 ms
```

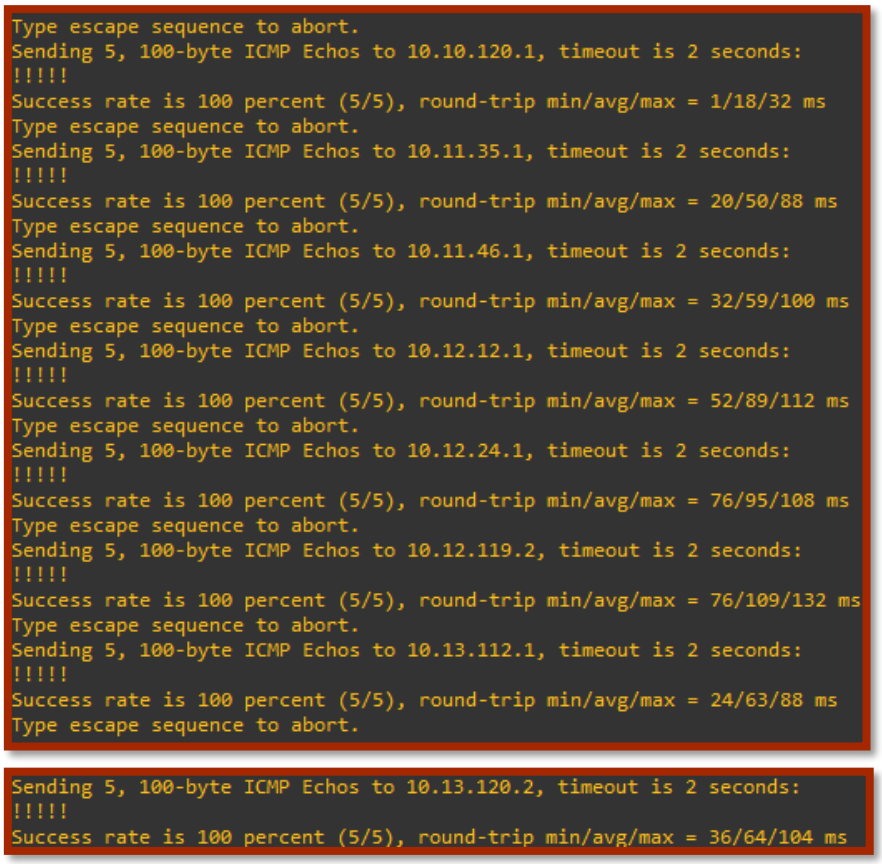


Figura 23 - Resultado dos pings

k)

Os routers ABR são routers que conectam uma ou mais áreas ao backbone. Neste ISP existem 4 ABR routers, o router R5, R6, R9 e R10. Para comprovar foi utilizado o comando **show ip ospf border-routers**. É possível também comprovar isto ao ver os LSAs do tipo Summary na base de dados do router 7.

```
                Summary Net Link States (Area 0)

Link ID         ADV Router      Age         Seq#       Checksum
10.10.35.0      5.5.5.5         1477        0x80000005 0x00658A
10.10.36.0      6.6.6.6         1311        0x80000005 0x003CAE
10.10.45.0      5.5.5.5         1477        0x80000005 0x00F6EE
10.10.46.0      6.6.6.6         1311        0x80000005 0x00CD13
10.10.119.0     9.9.9.9         1817        0x80000005 0x004D3E
10.10.119.0     10.10.10.10     676         0x80000005 0x00394D
10.10.119.0     11.11.11.11     78    (DNA) 0x80000001 0x002363
10.10.119.0     12.12.12.12     24    (DNA) 0x80000001 0x00057D
10.10.120.0     9.9.9.9         826         0x80000005 0x004C3D
10.10.120.0     10.10.10.10     677         0x80000005 0x002462
10.10.120.0     11.11.11.11     78    (DNA) 0x80000001 0x00186D
10.10.120.0     12.12.12.12     24    (DNA) 0x80000001 0x00F987
10.13.74.0      9.9.9.9         472         0x80000007 0x006D62
10.13.74.0      10.10.10.10     469         0x80000007 0x004F7C
10.13.74.0      11.11.11.11     78    (DNA) 0x80000001 0x003D90
10.13.74.0      12.12.12.12     24    (DNA) 0x80000001 0x001FAA
10.13.112.0     9.9.9.9         1017        0x80000001 0x00880A
10.13.112.0     10.10.10.10     1013        0x80000001 0x006A24
10.13.112.0     11.11.11.11     78    (DNA) 0x80000001 0x004249
10.13.112.0     12.12.12.12     24    (DNA) 0x80000001 0x002463
10.13.120.0     9.9.9.9         469         0x80000002 0x002E5B
10.13.120.0     10.10.10.10     465         0x80000002 0x001075
10.13.120.0     11.11.11.11     78    (DNA) 0x80000001 0x00F38E
10.13.120.0     12.12.12.12     24    (DNA) 0x80000001 0x00CBB3
30.39.1.0       9.9.9.9         1018        0x80000001 0x0014BF
30.39.1.0       10.10.10.10     1015        0x80000001 0x00F5D9
30.39.1.0       11.11.11.11     78    (DNA) 0x80000001 0x00CDFE
30.39.1.0       12.12.12.12     24    (DNA) 0x80000001 0x00B90E
30.39.2.0       9.9.9.9         470         0x80000002 0x0007CA
30.39.2.0       10.10.10.10     467         0x80000002 0x00E8E4
30.39.2.0       11.11.11.11     78    (DNA) 0x80000001 0x00CCFD
30.39.2.0       12.12.12.12     24    (DNA) 0x80000001 0x00A423
```

Figura 24 - LSA Type 3 Summary

```
R7#sh ip ospf border-routers

OSPF Process 1 internal Routing Table

Codes: i - Intra-area route, I - Inter-area route

i 4.4.4.4 [4] via 10.10.107.2, GigabitEthernet4/0, ABR, Area 0, SPF 14
i 4.4.4.4 [4] via 10.10.79.2, GigabitEthernet2/0, ABR, Area 0, SPF 14
i 19.19.19.19 [69] via 10.10.107.2, GigabitEthernet4/0, ABR, Area 0, SPF 14
i 19.19.19.19 [69] via 10.10.79.2, GigabitEthernet2/0, ABR, Area 0, SPF 14
i 12.12.12.12 [2] via 10.10.107.2, GigabitEthernet4/0, ABR, Area 0, SPF 14
i 1.1.1.1 [3] via 10.10.57.1, GigabitEthernet3/0, ABR, Area 0, SPF 14
i 5.5.5.5 [1] via 10.10.57.1, GigabitEthernet3/0, ABR, Area 0, SPF 14
i 9.9.9.9 [1] via 10.10.79.2, GigabitEthernet2/0, ABR, Area 0, SPF 14
i 2.2.2.2 [5] via 10.10.79.2, GigabitEthernet2/0, ABR, Area 0, SPF 14
i 2.2.2.2 [5] via 10.10.107.2, GigabitEthernet4/0, ABR, Area 0, SPF 14
i 6.6.6.6 [3] via 10.10.79.2, GigabitEthernet2/0, ABR, Area 0, SPF 14
i 6.6.6.6 [3] via 10.10.107.2, GigabitEthernet4/0, ABR, Area 0, SPF 14
i 10.10.10.10 [1] via 10.10.107.2, GigabitEthernet4/0, ABR, Area 0, SPF 14
i 3.3.3.3 [2] via 10.10.57.1, GigabitEthernet3/0, ABR, Area 0, SPF 14
i 11.11.11.11 [2] via 10.10.79.2, GigabitEthernet2/0, ABR, Area 0, SPF 14
```

Figura 25 - show ip ospf border-routers

l)

De acordo com os vizinhos de cada router ligado ao switch 1, o router R12 é o designated router (DR) e o router R11 é o backup designated router (BDR).
Podemos verificar isto com o comando show ip ospf interface, olhando para a interface Fa0/0 de cada router da rede do switch 1.

```
FastEthernet0/0 is up, line protocol is up
  Internet Address 10.13.74.2/27, Area 3
  Process ID 1, Router ID 10.10.10.10, Network Type BROADCAST, Cost: 1
  Transmit Delay is 1 sec, State DROTHER, Priority 1
  Designated Router (ID) 12.12.12.12, Interface address 10.13.74.4
  Backup Designated router (ID) 11.11.11.11, Interface address 10.13.74.3
  Timer intervals configured, Hello 10, Dead 40, Wait 40, Retransmit 5
    oob-resync timeout 40
    Hello due in 00:00:03
  Supports Link-local Signaling (LLS)
  Index 1/4, flood queue length 0
  Next 0x0(0)/0x0(0)
  Last flood scan length is 15, maximum is 15
  Last flood scan time is 0 msec, maximum is 4 msec
  Neighbor Count is 3, Adjacent neighbor count is 2
    Adjacent with neighbor 11.11.11.11  (Backup Designated Router)
    Adjacent with neighbor 12.12.12.12  (Designated Router)
```

m)

Realizando o comando **sh ip ospf database router adv-router 1.1.1.1** podemos verificar o custo OSPF do link s2/0. Esse custo é 64. Este valor é o default de um serial link, calculado com o valor da bandwith (100000000/1544000(bandwith) = 64.76).

```
R1#sh ip ospf database router adv-router 1.1.1.1

            OSPF Router with ID (1.1.1.1) (Process ID 1)

                Router Link States (Area 2)

  LS age: 488
  Options: (No TOS-capability, DC)
  LS Type: Router Links
  Link State ID: 1.1.1.1
  Advertising Router: 1.1.1.1
  LS Seq Number: 80000009
  Checksum: 0x7A1B
  Length: 72
  Number of Links: 4

    Link connected to: another Router (point-to-point)
     (Link ID) Neighboring Router ID: 19.19.19.19
     (Link Data) Router Interface address: 10.12.119.1
      Number of TOS metrics: 0
       TOS 0 Metrics: 64

    Link connected to: a Stub Network
     (Link ID) Network/subnet number: 10.12.119.0
     (Link Data) Network Mask: 255.255.255.252
      Number of TOS metrics: 0
       TOS 0 Metrics: 64

    Link connected to: a Transit Network
     (Link ID) Designated Router address: 10.12.12.1
     (Link Data) Router Interface address: 10.12.12.1
      Number of TOS metrics: 0
       TOS 0 Metrics: 10

    Link connected to: a Stub Network
     (Link ID) Network/subnet number: 10.12.13.0
     (Link Data) Network Mask: 255.255.255.252
      Number of TOS metrics: 0
       TOS 0 Metrics: 10
```

Figura 26 - Router Link States R1

n)

O tipo de rede OSPF inicialmente é Broadcast Multi-Access (BMA), ao realizar o comando **ip ospf network point-to-point** nas interfaces de cada router muda o tipo de network para PTP.

```
R5(config)#int g2/0
R5(config-if)#ip ospf network point-to-point
```

Figura 27 - Mudança do tipo de rede

Antes da execução do comando acima o estado do link é FULL/BDR, após passa a ser FULL/- e a prioridade passa de 1 a 0. Numa ligação PTP não existe eleição de DR/BDR.

```
R7#sh ip ospf neighbor

Neighbor ID     Pri   State           Dead Time   Address         Interface
10.10.10.10       1   FULL/DR         00:00:39    10.10.107.2     GigabitEthernet4/0
9.9.9.9           1   FULL/DR         00:00:38    10.10.79.2      GigabitEthernet2/0
5.5.5.5           1   FULL/BDR        00:00:33    10.10.57.1      GigabitEthernet3/0
```

Figura 28 - Rede BMA

```
R7#sh ip ospf neighbor

Neighbor ID     Pri   State           Dead Time   Address         Interface
10.10.10.10       1   FULL/DR         00:00:35    10.10.107.2     GigabitEthernet4/0
9.9.9.9           1   FULL/DR         00:00:39    10.10.79.2      GigabitEthernet2/0
5.5.5.5           0   FULL/  -        00:00:35    10.10.57.1      GigabitEthernet3/0
```

Figura 29 - Rede PTP

2. Configuração da rede do Cliente norte e ligação ao ISP

a)

Foi configurada a interface Fa1/0 e Fa0/0 do router R16 e o PC5 com os respetivos endereços de IP e mascáras.

```
interface FastEthernet0/0
 ip address 30.37.0.254 255.255.252.0
 duplex half
!
interface FastEthernet1/0
 ip address 40.9.0.2 255.255.255.252
 duplex auto
 speed auto
```

Figura 30 - Configuração R16

Foi também configurado router com o protocolo RIP versão 2 a anunciar as rotas do PC5 a que está ligado e a sua.

```
router rip
 version 2
 network 30.0.0.0
 network 40.0.0.0
 no auto-summary
```

Figura 31 - Configuração RIP

A configuração do PC5 é a seguinte:

```
PC5> ip 30.37.0.1/24 30.37.0.254
Checking for duplicate address...
PC1 : 30.37.0.1 255.255.255.0 gateway 30.37.0.254

PC5> sh ip

NAME        : PC5[1]
IP/MASK     : 30.37.0.1/24
GATEWAY     : 30.37.0.254
DNS         :
MAC         : 00:50:79:66:68:04
LPORT       : 10208
RHOST:PORT  : 127.0.0.1:10209
MTU:        : 1500
```

Figura 32 - Configuração PC5

Para haver partilha de rotas entre RIP e o OSPF foi necessário fazer algumas adições ao router R4, que faz a ligação do ISP com o cliente norte. Estas alterações consistem em configurar o router com o protocolo RIP e fazer a redistribuição das rotas.

A configuração do router R4 vai passar a ser a seguinte.

```
router ospf 1
 router-id 4.4.4.4
 log-adjacency-changes
 area 1 virtual-link 6.6.6.6
 area 2 virtual-link 2.2.2.2
 redistribute connected metric 400 subnets
 redistribute rip metric 400 metric-type 1 subnets
 passive-interface default
 no passive-interface FastEthernet0/0
 no passive-interface FastEthernet1/0
 no passive-interface GigabitEthernet2/0
 no passive-interface GigabitEthernet4/0
 network 10.11.45.0 0.0.0.3 area 1
 network 10.11.46.0 0.0.0.3 area 1
 network 10.12.24.0 0.0.0.3 area 2
 default-information originate
!
router rip
 version 2
 redistribute ospf 1 metric 12
 network 30.0.0.0
 network 40.0.0.0
```

Figura 33 - Configuração R4

A configuração RIP vai redistribuir as rotas do processo OSPF 1 para o cliente norte conseguir comunicar com o ISP. O comando **redistribute rip metric 400 metric-type 1 subnets** vai distribuir as rotas RIP para o OSPF.

b)

O comando **redistribute** usado nos ASBRs (Autonomous System Boundary Router) diz a um protocolo de encaminhamento para encaminhar as rotas de outro protocolo. Neste comando especifica-se qual o protocolo das rotas a serem encaminhadas pelo o router em questão. Por exemplo no router R4, o OSPF tem o trabalho de anunciar as rotas RIP que recebe e o RIP tem o trabalho de anunciar as rotas OSPF que recebe. O comando **network** serve para anunciar rotas que já estejam configuradas no OSPF.

c)

As rotas externas são divididas em duas categorias: o tipo 1 e o tipo 2. A diferença destes tipos está na forma em que o custo (métrica) da rota é calculado. O custo de uma rota tipo 2 é sempre o custo externo, independente do custo interior para alcançar aquela rota. Um custo de tipo 1 é a soma do custo externo e do custo interno utilizados para chegar ao router. Uma rota de tipo 1 é sempre preferível em relação a uma de tipo 2 porque o custo/caminho vai ser mais preciso e é mais fácil de perceber qual o melhor caminho.
Logo, as rotas externas devem ser do tipo 1 external.

d)

Foram verificadas as novas rotas em alguns routers representantes das várias áreas do ISP, usando o comando **show ip route**.

```
     40.0.0.0/30 is subnetted, 1 subnets
O E2    40.9.0.0 [110/400] via 10.10.107.2, 01:01:17, GigabitEthernet4/0
                 [110/400] via 10.10.79.2, 01:01:17, GigabitEthernet2/0
     10.0.0.0/8 is variably subnetted, 21 subnets, 3 masks
O IA    10.12.12.0/30 [110/13] via 10.10.57.1, 01:01:17, GigabitEthernet3/0
O IA    10.12.13.0/30 [110/3] via 10.10.57.1, 01:01:17, GigabitEthernet3/0
O IA    10.12.24.0/30 [110/5] via 10.10.107.2, 01:01:17, GigabitEthernet4/0
                      [110/5] via 10.10.79.2, 01:01:17, GigabitEthernet2/0
O IA    10.11.35.0/30 [110/2] via 10.10.57.1, 01:01:17, GigabitEthernet3/0
O IA    10.11.36.0/30 [110/3] via 10.10.57.1, 01:01:17, GigabitEthernet3/0
O IA    10.11.45.0/30 [110/2] via 10.10.57.1, 01:01:17, GigabitEthernet3/0
O IA    10.11.46.0/30 [110/3] via 10.10.57.1, 01:01:17, GigabitEthernet3/0
C       10.10.57.0/30 is directly connected, GigabitEthernet3/0
O       10.10.68.0/30 [110/3] via 10.10.107.2, 01:01:18, GigabitEthernet4/0
                      [110/3] via 10.10.79.2, 01:01:18, GigabitEthernet2/0
O IA    10.13.74.0/27 [110/2] via 10.10.107.2, 01:01:18, GigabitEthernet4/0
                      [110/2] via 10.10.79.2, 01:01:18, GigabitEthernet2/0
C       10.10.79.0/30 is directly connected, GigabitEthernet2/0
O       10.10.89.0/30 [110/2] via 10.10.79.2, 01:01:18, GigabitEthernet2/0
C       10.10.107.0/30 is directly connected, GigabitEthernet4/0
O       10.10.108.0/30 [110/2] via 10.10.107.2, 01:01:18, GigabitEthernet4/0
O IA    10.13.119.0/30 [110/2] via 10.10.79.2, 01:01:19, GigabitEthernet2/0
O IA    10.12.119.0/30 [110/67] via 10.10.57.1, 01:01:19, GigabitEthernet3/0
O IA    10.13.121.0/30 [110/3] via 10.10.107.2, 01:01:19, GigabitEthernet4/0
                       [110/3] via 10.10.79.2, 01:01:19, GigabitEthernet2/0
O IA    10.13.120.0/30 [110/2] via 10.10.107.2, 01:01:19, GigabitEthernet4/0
O IA    10.12.219.0/30 [110/69] via 10.10.107.2, 01:01:19, GigabitEthernet4/0
                       [110/69] via 10.10.79.2, 01:01:19, GigabitEthernet2/0
C       10.255.7.7/32 is directly connected, Loopback0
O E2    10.255.4.4/32 [110/400] via 10.10.107.2, 01:01:19, GigabitEthernet4/0
                      [110/400] via 10.10.79.2, 01:01:19, GigabitEthernet2/0
     30.0.0.0/8 is variably subnetted, 4 subnets, 2 masks
O IA    30.39.1.0/30 [110/3] via 10.10.107.2, 01:01:19, GigabitEthernet4/0
                     [110/3] via 10.10.79.2, 01:01:19, GigabitEthernet2/0
O IA    30.39.3.0/30 [110/77] via 10.10.57.1, 01:01:19, GigabitEthernet3/0
O IA    30.39.2.0/30 [110/3] via 10.10.107.2, 01:01:19, GigabitEthernet4/0
                     [110/3] via 10.10.79.2, 01:01:19, GigabitEthernet2/0
O E1    30.37.0.0/22 [110/404] via 10.10.107.2, 00:20:49, GigabitEthernet4/0
                     [110/404] via 10.10.79.2, 00:20:49, GigabitEthernet2/0
```

Figura 34 - Tabela R7

```
     40.0.0.0/30 is subnetted, 1 subnets
O E2    40.9.0.0 [110/400] via 10.12.219.1, 01:05:27, Serial2/1
     10.0.0.0/8 is variably subnetted, 21 subnets, 3 masks
O       10.12.12.0/30 [110/74] via 10.12.219.1, 01:05:27, Serial2/1
                      [110/74] via 10.12.119.1, 01:05:27, Serial2/0
O       10.12.13.0/30 [110/74] via 10.12.119.1, 01:05:27, Serial2/0
O       10.12.24.0/30 [110/74] via 10.12.219.1, 01:05:27, Serial2/1
O IA    10.11.35.0/30 [110/75] via 10.12.119.1, 01:05:12, Serial2/0
O IA    10.11.36.0/30 [110/75] via 10.12.119.1, 01:05:14, Serial2/0
O IA    10.11.45.0/30 [110/75] via 10.12.219.1, 01:05:14, Serial2/1
O IA    10.11.46.0/30 [110/75] via 10.12.219.1, 01:05:14, Serial2/1
O       10.10.57.0/30 [110/76] via 10.12.219.1, 01:00:22, Serial2/1
                      [110/76] via 10.12.119.1, 01:05:14, Serial2/0
O       10.10.68.0/30 [110/76] via 10.12.219.1, 01:05:11, Serial2/1
                      [110/76] via 10.12.119.1, 01:00:22, Serial2/0
O IA    10.13.74.0/27 [110/78] via 10.12.219.1, 00:32:48, Serial2/1
                      [110/78] via 10.12.119.1, 01:05:14, Serial2/0
O       10.10.79.0/30 [110/77] via 10.12.119.1, 01:05:14, Serial2/0
O       10.10.89.0/30 [110/77] via 10.12.219.1, 01:05:14, Serial2/1
                      [110/77] via 10.12.119.1, 01:00:22, Serial2/0
O       10.10.107.0/30 [110/77] via 10.12.119.1, 01:05:16, Serial2/0
O       10.10.108.0/30 [110/77] via 10.12.219.1, 01:05:16, Serial2/1
                       [110/77] via 10.12.119.1, 01:00:24, Serial2/0
O IA    10.13.119.0/30 [110/78] via 10.12.219.1, 01:05:16, Serial2/1
                       [110/78] via 10.12.119.1, 01:05:16, Serial2/0
C       10.12.119.0/30 is directly connected, Serial2/0
O IA    10.13.121.0/30 [110/79] via 10.12.219.1, 00:32:50, Serial2/1
                       [110/79] via 10.12.119.1, 01:03:09, Serial2/0
O IA    10.13.120.0/30 [110/78] via 10.12.219.1, 01:02:49, Serial2/1
                       [110/78] via 10.12.119.1, 01:02:51, Serial2/0
C       10.12.219.0/30 is directly connected, Serial2/1
C       10.255.19.19/32 is directly connected, Loopback0
O E2    10.255.4.4/32 [110/400] via 10.12.219.1, 01:05:33, Serial2/1
     30.0.0.0/8 is variably subnetted, 4 subnets, 2 masks
O IA    30.39.1.0/30 [110/79] via 10.12.219.1, 00:32:52, Serial2/1
                     [110/79] via 10.12.119.1, 01:05:18, Serial2/0
C       30.39.3.0/30 is directly connected, FastEthernet0/0
O IA    30.39.2.0/30 [110/79] via 10.12.219.1, 00:32:52, Serial2/1
                     [110/79] via 10.12.119.1, 01:05:18, Serial2/0
O E1    30.37.0.0/22 [110/474] via 10.12.219.1, 00:20:02, Serial2/1
```

Figura 35 - Tabela R19

```
     40.0.0.0/30 is subnetted, 1 subnets
O E2    40.9.0.0 [110/400] via 10.13.74.2, 00:58:46, FastEthernet0/0
                 [110/400] via 10.13.74.1, 00:58:46, FastEthernet0/0
     10.0.0.0/8 is variably subnetted, 20 subnets, 3 masks
O IA    10.12.12.0/30 [110/15] via 10.13.74.2, 00:58:46, FastEthernet0/0
                      [110/15] via 10.13.74.1, 00:58:46, FastEthernet0/0
O IA    10.12.13.0/30 [110/5] via 10.13.74.2, 00:58:46, FastEthernet0/0
                      [110/5] via 10.13.74.1, 00:58:46, FastEthernet0/0
O IA    10.12.24.0/30 [110/5] via 10.13.74.2, 00:58:46, FastEthernet0/0
                      [110/5] via 10.13.74.1, 00:58:46, FastEthernet0/0
O IA    10.11.35.0/30 [110/4] via 10.13.74.2, 00:58:46, FastEthernet0/0
                      [110/4] via 10.13.74.1, 00:58:46, FastEthernet0/0
O IA    10.11.36.0/30 [110/4] via 10.13.74.2, 00:58:46, FastEthernet0/0
                      [110/4] via 10.13.74.1, 00:58:46, FastEthernet0/0
O IA    10.11.45.0/30 [110/4] via 10.13.74.2, 00:58:48, FastEthernet0/0
                      [110/4] via 10.13.74.1, 00:58:48, FastEthernet0/0
O IA    10.11.46.0/30 [110/4] via 10.13.74.2, 00:58:48, FastEthernet0/0
                      [110/4] via 10.13.74.1, 00:58:48, FastEthernet0/0
O       10.10.57.0/30 [110/3] via 10.13.74.2, 00:58:48, FastEthernet0/0
                      [110/3] via 10.13.74.1, 00:58:48, FastEthernet0/0
O       10.10.68.0/30 [110/3] via 10.13.74.2, 00:58:48, FastEthernet0/0
                      [110/3] via 10.13.74.1, 00:58:48, FastEthernet0/0
C       10.13.74.0/27 is directly connected, FastEthernet0/0
O       10.10.79.0/30 [110/2] via 10.13.74.1, 00:58:49, FastEthernet0/0
O       10.10.89.0/30 [110/2] via 10.13.74.1, 00:58:49, FastEthernet0/0
O       10.10.107.0/30 [110/2] via 10.13.74.2, 00:58:44, FastEthernet0/0
O       10.10.108.0/30 [110/2] via 10.13.74.2, 00:58:44, FastEthernet0/0
C       10.13.119.0/30 is directly connected, GigabitEthernet3/0
O IA    10.12.119.0/30 [110/69] via 10.13.74.2, 00:58:49, FastEthernet0/0
                       [110/69] via 10.13.74.1, 00:58:49, FastEthernet0/0
C       10.13.121.0/30 is directly connected, GigabitEthernet4/0
O       10.13.120.0/30 [110/2] via 10.13.121.2, 00:58:59, GigabitEthernet4/0
                       [110/2] via 10.13.74.4, 00:58:59, FastEthernet0/0
                       [110/2] via 10.13.74.2, 00:58:59, FastEthernet0/0
O IA    10.12.219.0/30 [110/69] via 10.13.74.2, 00:58:49, FastEthernet0/0
                       [110/69] via 10.13.74.1, 00:58:49, FastEthernet0/0
O E2    10.255.4.4/32 [110/400] via 10.13.74.2, 00:58:49, FastEthernet0/0
                      [110/400] via 10.13.74.1, 00:58:49, FastEthernet0/0
     30.0.0.0/8 is variably subnetted, 4 subnets, 2 masks
C       30.39.1.0/30 is directly connected, FastEthernet1/0
O IA    30.39.3.0/30 [110/79] via 10.13.74.2, 00:58:50, FastEthernet0/0
                     [110/79] via 10.13.74.1, 00:58:50, FastEthernet0/0
O       30.39.2.0/30 [110/2] via 10.13.121.2, 00:59:00, GigabitEthernet4/0
                     [110/2] via 10.13.74.4, 00:59:00, FastEthernet0/0
O E1    30.37.0.0/22 [110/404] via 10.13.74.2, 00:18:25, FastEthernet0/0
                     [110/404] via 10.13.74.1, 00:18:25, FastEthernet0/0
```

Figura 36 - Tabela R11

```
     40.0.0.0/30 is subnetted, 1 subnets
O E2    40.9.0.0 [110/400] via 10.11.46.1, 00:14:33, GigabitEthernet3/0
     10.0.0.0/8 is variably subnetted, 21 subnets, 3 masks
O IA    10.12.12.0/30 [110/12] via 10.11.46.1, 00:14:43, GigabitEthernet3/0
                      [110/12] via 10.11.36.1, 00:14:43, GigabitEthernet4/0
O IA    10.12.13.0/30 [110/2] via 10.11.36.1, 00:14:43, GigabitEthernet4/0
O IA    10.12.24.0/30 [110/2] via 10.11.46.1, 00:14:43, GigabitEthernet3/0
O       10.11.35.0/30 [110/2] via 10.11.36.1, 00:14:43, GigabitEthernet4/0
C       10.11.36.0/30 is directly connected, GigabitEthernet4/0
O       10.11.45.0/30 [110/2] via 10.11.46.1, 00:14:43, GigabitEthernet3/0
C       10.11.46.0/30 is directly connected, GigabitEthernet3/0
O       10.10.57.0/30 [110/3] via 10.11.46.1, 00:14:43, GigabitEthernet3/0
                      [110/3] via 10.11.36.1, 00:14:43, GigabitEthernet4/0
C       10.10.68.0/30 is directly connected, GigabitEthernet2/0
O IA    10.13.74.0/27 [110/3] via 10.10.68.2, 00:14:44, GigabitEthernet2/0
O       10.10.79.0/30 [110/3] via 10.10.68.2, 00:42:04, GigabitEthernet2/0
O       10.10.89.0/30 [110/2] via 10.10.68.2, 00:42:04, GigabitEthernet2/0
O       10.10.107.0/30 [110/3] via 10.10.68.2, 00:42:04, GigabitEthernet2/0
O       10.10.108.0/30 [110/2] via 10.10.68.2, 00:42:04, GigabitEthernet2/0
O IA    10.13.119.0/30 [110/3] via 10.10.68.2, 00:14:44, GigabitEthernet2/0
O IA    10.12.119.0/30 [110/66] via 10.11.36.1, 00:14:44, GigabitEthernet4/0
O IA    10.13.121.0/30 [110/4] via 10.10.68.2, 00:14:44, GigabitEthernet2/0
O IA    10.13.120.0/30 [110/3] via 10.10.68.2, 00:14:44, GigabitEthernet2/0
O IA    10.12.219.0/30 [110/66] via 10.11.46.1, 00:14:45, GigabitEthernet3/0
C       10.255.6.6/32 is directly connected, Loopback0
O E2    10.255.4.4/32 [110/400] via 10.11.46.1, 00:14:35, GigabitEthernet3/0
     30.0.0.0/8 is variably subnetted, 4 subnets, 2 masks
O IA    30.39.1.0/30 [110/4] via 10.10.68.2, 00:14:45, GigabitEthernet2/0
O IA    30.39.3.0/30 [110/76] via 10.11.46.1, 00:14:45, GigabitEthernet3/0
                     [110/76] via 10.11.36.1, 00:14:45, GigabitEthernet4/0
O IA    30.39.2.0/30 [110/4] via 10.10.68.2, 00:14:45, GigabitEthernet2/0
O E1    30.37.0.0/22 [110/401] via 10.11.46.1, 00:01:35, GigabitEthernet3/0
```

Figura 37 - Tabela R6

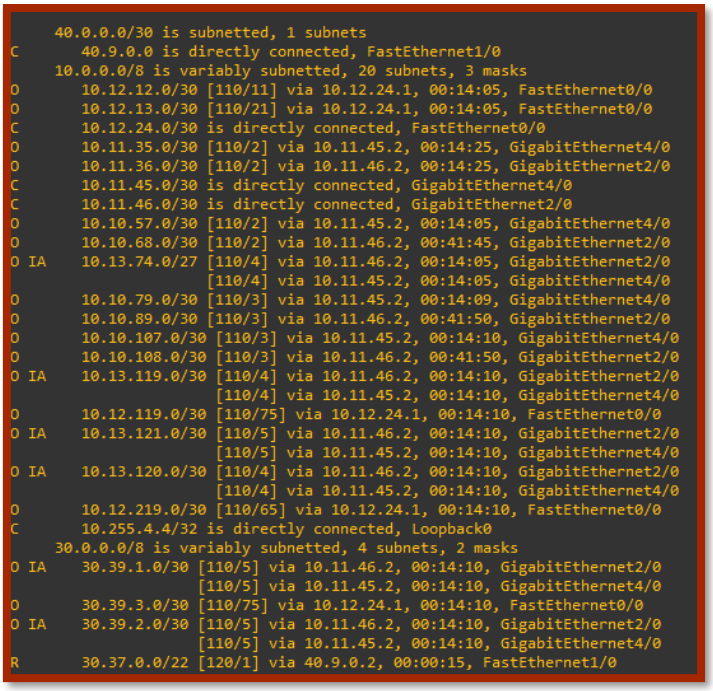


Figura 38 - Tabela R4

e)

Foi feito um ping múltiplo utilizando o comando tclsh para verificar a conectividade ao ISP por parte do cliente norte.

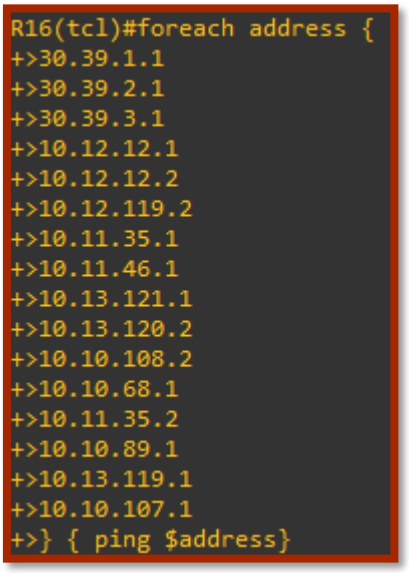


Figura 39 - Ping múltiplo

```
Type escape sequence to abort.
Sending 5, 100-byte ICMP Echos to 30.39.1.1, timeout is 2 seconds:
.!!!!
Success rate is 80 percent (4/5), round-trip min/avg/max = 96/128/148 ms
Type escape sequence to abort.
Sending 5, 100-byte ICMP Echos to 30.39.2.1, timeout is 2 seconds:
.!!!!
Success rate is 80 percent (4/5), round-trip min/avg/max = 116/137/148 ms
Type escape sequence to abort.
Sending 5, 100-byte ICMP Echos to 30.39.3.1, timeout is 2 seconds:
.!!!!
Success rate is 80 percent (4/5), round-trip min/avg/max = 88/108/132 ms
Type escape sequence to abort.
Sending 5, 100-byte ICMP Echos to 10.12.12.1, timeout is 2 seconds:
!!!!!
Success rate is 100 percent (5/5), round-trip min/avg/max = 88/94/116 ms
Type escape sequence to abort.
Sending 5, 100-byte ICMP Echos to 10.12.12.2, timeout is 2 seconds:
!!!!!
Success rate is 100 percent (5/5), round-trip min/avg/max = 60/84/100 ms
Type escape sequence to abort.
Sending 5, 100-byte ICMP Echos to 10.12.119.2, timeout is 2 seconds:
!!!!!
Success rate is 100 percent (5/5), round-trip min/avg/max = 88/93/116 ms
Type escape sequence to abort.
Sending 5, 100-byte ICMP Echos to 10.11.35.1, timeout is 2 seconds:
!!!!!
Success rate is 100 percent (5/5), round-trip min/avg/max = 88/90/96 ms
Type escape sequence to abort.
Sending 5, 100-byte ICMP Echos to 10.11.46.1, timeout is 2 seconds:
!!!!!
Success rate is 100 percent (5/5), round-trip min/avg/max = 60/60/64 ms
Type escape sequence to abort.
Sending 5, 100-byte ICMP Echos to 10.13.121.1, timeout is 2 seconds:
!!!!!
Success rate is 100 percent (5/5), round-trip min/avg/max = 116/133/148 ms
```

```
Type escape sequence to abort.
Sending 5, 100-byte ICMP Echos to 10.13.120.2, timeout is 2 seconds:
!!!!!
Success rate is 100 percent (5/5), round-trip min/avg/max = 120/137/148 ms
Type escape sequence to abort.
Sending 5, 100-byte ICMP Echos to 10.10.108.2, timeout is 2 seconds:
!!!!!
Success rate is 100 percent (5/5), round-trip min/avg/max = 116/120/128 ms
Type escape sequence to abort.
Sending 5, 100-byte ICMP Echos to 10.10.68.1, timeout is 2 seconds:
!!!!!
Success rate is 100 percent (5/5), round-trip min/avg/max = 88/88/92 ms
Type escape sequence to abort.
Sending 5, 100-byte ICMP Echos to 10.11.35.2, timeout is 2 seconds:
!!!!!
Success rate is 100 percent (5/5), round-trip min/avg/max = 60/76/100 ms
Type escape sequence to abort.
Sending 5, 100-byte ICMP Echos to 10.10.89.1, timeout is 2 seconds:
!!!!!
Success rate is 100 percent (5/5), round-trip min/avg/max = 88/95/120 ms
Type escape sequence to abort.
Sending 5, 100-byte ICMP Echos to 10.13.119.1, timeout is 2 seconds:
!!!!!
Success rate is 100 percent (5/5), round-trip min/avg/max = 116/120/128 ms
Type escape sequence to abort.
Sending 5, 100-byte ICMP Echos to 10.10.107.1, timeout is 2 seconds:
!!!!!
Success rate is 100 percent (5/5), round-trip min/avg/max = 116/119/124 ms
```

Figura 40 - Resultado do ping

3. Configuração da rede do Cliente Sul e ligação ao ISP

a)

Foram configuradas as redes das interfaces do router R12 e router R18 do cliente sul.

Para o router R12 foram configuradas as seguintes interfaces.

```
interface Loopback0
 ip address 10.255.12.12 255.255.255.0
!
interface Loopback1
 ip address 20.0.1.1 255.255.255.0
!
interface Loopback2
 ip address 20.0.2.1 255.255.255.0
!
interface Loopback3
 ip address 20.0.3.1 255.255.255.0
!
interface FastEthernet0/0
 ip address 10.13.74.4 255.255.255.224
 duplex half
!
interface FastEthernet1/0
 ip address 30.39.2.2 255.255.255.252
 duplex auto
 speed auto
!
interface FastEthernet1/1
 ip address 40.9.3.1 255.255.255.252
 duplex auto
 speed auto
!
```

Figura 41 - Configuração R12

Para a redistribuição mútua foi necessário adicionar algumas configurações ao OSPF do router R12 e configurar o protocolo RIP.

```
router ospf 1
 router-id 12.12.12.12
 log-adjacency-changes
 area 3 virtual-link 10.10.10.10
 redistribute connected metric 1200 subnets
 redistribute rip metric 1200 metric-type 1 subnets
 passive-interface default
 no passive-interface FastEthernet0/0
 no passive-interface FastEthernet1/0
 no passive-interface FastEthernet1/1
 no passive-interface GigabitEthernet3/0
 no passive-interface GigabitEthernet4/0
 network 10.13.74.0 0.0.0.31 area 3
 network 10.13.112.0 0.0.0.3 area 3
 network 10.13.120.0 0.0.0.3 area 3
 network 10.13.121.0 0.0.0.3 area 3
 network 30.39.2.0 0.0.0.3 area 3
 default-information originate
```

Figura 43 - Configuração OSPF do R12

```
router rip
 version 2
 redistribute ospf 1 metric 12
 network 30.0.0.0
 network 40.0.0.0
```

Figura 42 - Configuração RIP do R12

Depois foram configurados componentes do cliente sul as 2 interfaces do router R18 e o PC7.

```
interface FastEthernet1/0
 ip address 30.38.0.254 255.255.252.0
 duplex auto
 speed auto
!
interface FastEthernet1/1
 ip address 40.9.3.2 255.255.255.252
 duplex auto
 speed auto
```

```
router rip
 version 2
 redistribute ospf 1 metric 12
 network 30.0.0.0
 network 40.0.0.0
```

Figura 44 - Configuração R18

O PC7 tem o endereço de IP 30.38.0.1 255.255.255.0 com o endereço de gateway a rede interface Fa1/0 do router R18.

```
PC7> ip 30.38.0.1/24 30.38.0.254
Checking for duplicate address...
PC1 : 30.38.0.1 255.255.255.0 gateway 30.38.0.254

PC7> sh ip

NAME        : PC7[1]
IP/MASK     : 30.38.0.1/24
GATEWAY     : 30.38.0.254
DNS         :
MAC         : 00:50:79:66:68:06
LPORT       : 10212
RHOST:PORT  : 127.0.0.1:10213
MTU:        : 1500
```

Figura 45 - Configuração PC7

b)

Na tabela de routing podemos confirmar as rotas OSPF no router R18.

```
R18#sh ip route
Codes: C - connected, S - static, R - RIP, M - mobile, B - BGP
       D - EIGRP, EX - EIGRP external, O - OSPF, IA - OSPF inter area
       N1 - OSPF NSSA external type 1, N2 - OSPF NSSA external type 2
       E1 - OSPF external type 1, E2 - OSPF external type 2
       i - IS-IS, su - IS-IS summary, L1 - IS-IS level-1, L2 - IS-IS level-2
       ia - IS-IS inter area, * - candidate default, U - per-user static route
       o - ODR, P - periodic downloaded static route

Gateway of last resort is not set

     40.0.0.0/30 is subnetted, 2 subnets
R       40.9.0.0 [120/12] via 40.9.3.1, 00:00:07, FastEthernet1/1
C       40.9.3.0 is directly connected, FastEthernet1/1
R    10.0.0.0/8 [120/12] via 40.9.3.1, 00:00:07, FastEthernet1/1
     30.0.0.0/8 is variably subnetted, 2 subnets, 2 masks
R       30.0.0.0/8 [120/12] via 40.9.3.1, 00:00:07, FastEthernet1/1
C       30.38.0.0/22 is directly connected, FastEthernet1/0
```

Figura 46 - show ip route R18

c)

Foram verificadas as novas rotas em alguns routers representantes das várias áreas do ISP, usando o comando **show ip route**.

```
     20.0.0.0/24 is subnetted, 3 subnets
O E2    20.0.1.0 [110/1200] via 10.13.121.2, 00:24:37, GigabitEthernet4/0
                 [110/1200] via 10.13.74.4, 00:24:37, FastEthernet0/0
O E2    20.0.2.0 [110/1200] via 10.13.121.2, 00:24:37, GigabitEthernet4/0
                 [110/1200] via 10.13.74.4, 00:24:37, FastEthernet0/0
O E2    20.0.3.0 [110/1200] via 10.13.121.2, 00:24:37, GigabitEthernet4/0
                 [110/1200] via 10.13.74.4, 00:24:37, FastEthernet0/0
     40.0.0.0/30 is subnetted, 2 subnets
O E2    40.9.0.0 [110/400] via 10.13.74.2, 00:24:37, FastEthernet0/0
                 [110/400] via 10.13.74.1, 00:24:37, FastEthernet0/0
O E2    40.9.3.0 [110/1200] via 10.13.121.2, 00:24:37, GigabitEthernet4/0
                 [110/1200] via 10.13.74.4, 00:24:37, FastEthernet0/0
     10.0.0.0/8 is variably subnetted, 21 subnets, 4 masks
O IA    10.12.12.0/30 [110/15] via 10.13.74.2, 00:24:38, FastEthernet0/0
                      [110/15] via 10.13.74.1, 00:24:38, FastEthernet0/0
O IA    10.12.13.0/30 [110/5] via 10.13.74.2, 00:24:38, FastEthernet0/0
                      [110/5] via 10.13.74.1, 00:24:38, FastEthernet0/0
O IA    10.12.24.0/30 [110/5] via 10.13.74.2, 00:24:39, FastEthernet0/0
                      [110/5] via 10.13.74.1, 00:24:39, FastEthernet0/0
O IA    10.11.35.0/30 [110/4] via 10.13.74.2, 00:24:39, FastEthernet0/0
                      [110/4] via 10.13.74.1, 00:24:39, FastEthernet0/0
O IA    10.11.36.0/30 [110/4] via 10.13.74.2, 00:24:39, FastEthernet0/0
                      [110/4] via 10.13.74.1, 00:24:39, FastEthernet0/0
O IA    10.11.45.0/30 [110/4] via 10.13.74.2, 00:24:39, FastEthernet0/0
                      [110/4] via 10.13.74.1, 00:24:39, FastEthernet0/0
O IA    10.11.46.0/30 [110/4] via 10.13.74.2, 00:24:39, FastEthernet0/0
                      [110/4] via 10.13.74.1, 00:24:39, FastEthernet0/0
O       10.10.57.0/30 [110/3] via 10.13.74.2, 00:24:39, FastEthernet0/0
                      [110/3] via 10.13.74.1, 00:24:39, FastEthernet0/0
O       10.10.68.0/30 [110/3] via 10.13.74.2, 00:24:39, FastEthernet0/0
                      [110/3] via 10.13.74.1, 00:24:39, FastEthernet0/0
C       10.13.74.0/27 is directly connected, FastEthernet0/0
O       10.10.79.0/30 [110/2] via 10.13.74.1, 00:25:01, FastEthernet0/0
O       10.10.89.0/30 [110/2] via 10.13.74.1, 00:25:01, FastEthernet0/0
O       10.10.107.0/30 [110/2] via 10.13.74.2, 00:25:01, FastEthernet0/0
O       10.10.108.0/30 [110/2] via 10.13.74.2, 00:25:01, FastEthernet0/0
C       10.13.119.0/30 is directly connected, GigabitEthernet3/0
O IA    10.12.119.0/30 [110/69] via 10.13.74.2, 00:25:01, FastEthernet0/0
                       [110/69] via 10.13.74.1, 00:25:01, FastEthernet0/0
C       10.13.121.0/30 is directly connected, GigabitEthernet4/0
O       10.13.120.0/30 [110/2] via 10.13.121.2, 00:26:02, GigabitEthernet4/0
                       [110/2] via 10.13.74.4, 00:26:02, FastEthernet0/0
                       [110/2] via 10.13.74.2, 00:26:02, FastEthernet0/0
O IA    10.12.219.0/30 [110/69] via 10.13.74.2, 00:25:02, FastEthernet0/0
                       [110/69] via 10.13.74.1, 00:25:02, FastEthernet0/0
O E2    10.255.4.4/32 [110/400] via 10.13.74.2, 00:25:02, FastEthernet0/0
                      [110/400] via 10.13.74.1, 00:25:02, FastEthernet0/0
O E2    10.255.12.0/24
          [110/1200] via 10.13.121.2, 00:25:02, GigabitEthernet4/0
          [110/1200] via 10.13.74.4, 00:25:02, FastEthernet0/0
     30.0.0.0/8 is variably subnetted, 5 subnets, 2 masks
C       30.39.1.0/30 is directly connected, FastEthernet1/0
O E1    30.38.0.0/22 [110/1201] via 10.13.121.2, 00:25:03, GigabitEthernet4/0
                     [110/1201] via 10.13.74.4, 00:25:03, FastEthernet0/0
O IA    30.39.3.0/30 [110/79] via 10.13.74.2, 00:25:03, FastEthernet0/0
                     [110/79] via 10.13.74.1, 00:25:03, FastEthernet0/0
O       30.39.2.0/30 [110/2] via 10.13.121.2, 00:26:05, GigabitEthernet4/0
                     [110/2] via 10.13.74.4, 00:26:05, FastEthernet0/0
O E1    30.37.0.0/22 [110/404] via 10.13.74.2, 00:25:06, FastEthernet0/0
                     [110/404] via 10.13.74.1, 00:25:06, FastEthernet0/0
```

Figura 47 - Tabela R11

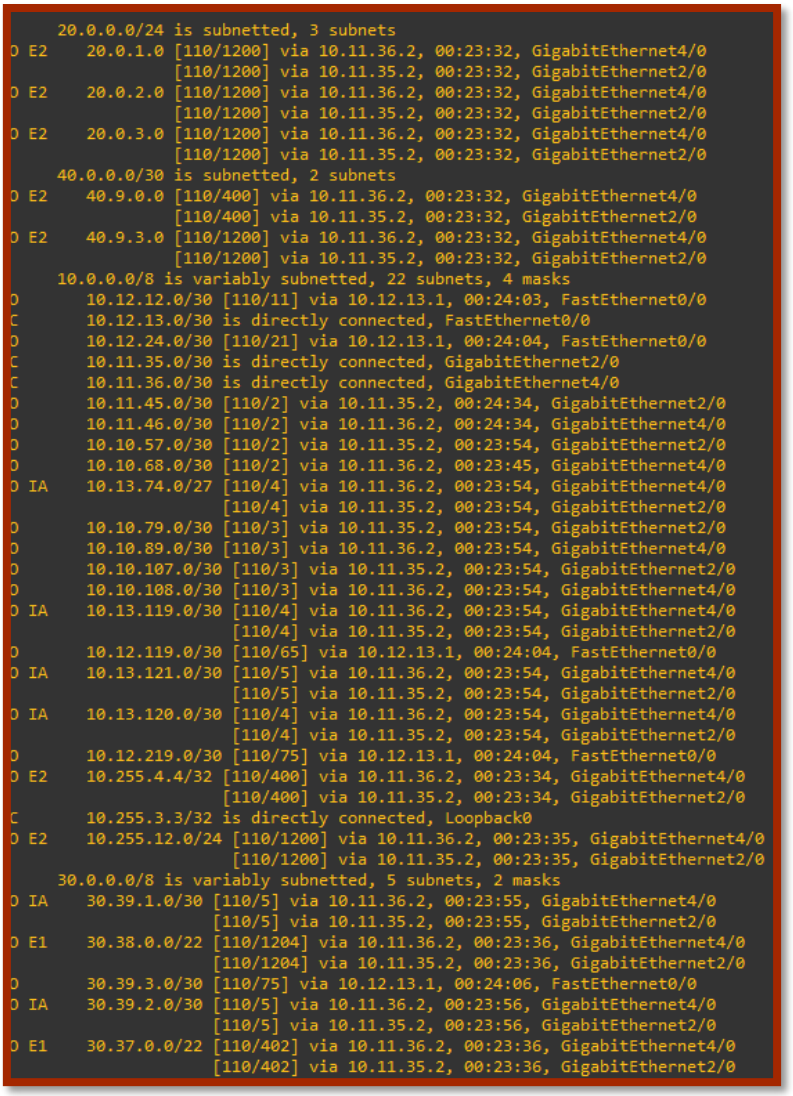


Figura 48 - Tabela R3

```
     20.0.0.0/24 is subnetted, 3 subnets
O E2    20.0.1.0 [110/1200] via 10.10.107.2, 00:22:46, GigabitEthernet4/0
O E2    20.0.2.0 [110/1200] via 10.10.107.2, 00:22:46, GigabitEthernet4/0
O E2    20.0.3.0 [110/1200] via 10.10.107.2, 00:22:46, GigabitEthernet4/0
     40.0.0.0/30 is subnetted, 2 subnets
O E2    40.9.0.0 [110/400] via 10.10.107.2, 00:22:46, GigabitEthernet4/0
                 [110/400] via 10.10.79.2, 00:22:46, GigabitEthernet2/0
O E2    40.9.3.0 [110/1200] via 10.10.107.2, 00:22:46, GigabitEthernet4/0
     10.0.0.0/8 is variably subnetted, 22 subnets, 4 masks
O IA    10.12.12.0/30 [110/13] via 10.10.57.1, 00:22:46, GigabitEthernet3/0
O IA    10.12.13.0/30 [110/3] via 10.10.57.1, 00:22:46, GigabitEthernet3/0
O IA    10.12.24.0/30 [110/5] via 10.10.107.2, 00:22:46, GigabitEthernet4/0
                      [110/5] via 10.10.79.2, 00:22:46, GigabitEthernet2/0
O IA    10.11.35.0/30 [110/2] via 10.10.57.1, 00:22:47, GigabitEthernet3/0
O IA    10.11.36.0/30 [110/3] via 10.10.57.1, 00:22:47, GigabitEthernet3/0
O IA    10.11.45.0/30 [110/2] via 10.10.57.1, 00:22:47, GigabitEthernet3/0
O IA    10.11.46.0/30 [110/3] via 10.10.57.1, 00:22:47, GigabitEthernet3/0
C       10.10.57.0/30 is directly connected, GigabitEthernet3/0
O       10.10.68.0/30 [110/3] via 10.10.107.2, 00:22:47, GigabitEthernet4/0
                      [110/3] via 10.10.79.2, 00:22:47, GigabitEthernet2/0
O IA    10.13.74.0/27 [110/2] via 10.10.107.2, 00:22:47, GigabitEthernet4/0
                      [110/2] via 10.10.79.2, 00:22:47, GigabitEthernet2/0
C       10.10.79.0/30 is directly connected, GigabitEthernet2/0
O       10.10.89.0/30 [110/2] via 10.10.79.2, 00:22:47, GigabitEthernet2/0
C       10.10.107.0/30 is directly connected, GigabitEthernet4/0
O       10.10.108.0/30 [110/2] via 10.10.107.2, 00:22:47, GigabitEthernet4/0
O IA    10.13.119.0/30 [110/2] via 10.10.79.2, 00:22:47, GigabitEthernet2/0
O IA    10.12.119.0/30 [110/67] via 10.10.57.1, 00:22:47, GigabitEthernet3/0
O IA    10.13.121.0/30 [110/3] via 10.10.107.2, 00:22:47, GigabitEthernet4/0
                       [110/3] via 10.10.79.2, 00:22:47, GigabitEthernet2/0
O IA    10.13.120.0/30 [110/2] via 10.10.107.2, 00:22:48, GigabitEthernet4/0
O IA    10.12.219.0/30 [110/69] via 10.10.107.2, 00:22:48, GigabitEthernet4/0
                       [110/69] via 10.10.79.2, 00:22:48, GigabitEthernet2/0
C       10.255.7.7/32 is directly connected, Loopback0
O E2    10.255.4.4/32 [110/400] via 10.10.107.2, 00:22:48, GigabitEthernet4/0
                      [110/400] via 10.10.79.2, 00:22:48, GigabitEthernet2/0
O E2    10.255.12.0/24
          [110/1200] via 10.10.107.2, 00:22:48, GigabitEthernet4/0
     30.0.0.0/8 is variably subnetted, 5 subnets, 2 masks
O IA    30.39.1.0/30 [110/3] via 10.10.107.2, 00:22:48, GigabitEthernet4/0
                     [110/3] via 10.10.79.2, 00:22:48, GigabitEthernet2/0
O E1    30.38.0.0/22 [110/1202] via 10.10.107.2, 00:22:48, GigabitEthernet4/0
O IA    30.39.3.0/30 [110/77] via 10.10.57.1, 00:22:48, GigabitEthernet3/0
O IA    30.39.2.0/30 [110/3] via 10.10.107.2, 00:22:49, GigabitEthernet4/0
                     [110/3] via 10.10.79.2, 00:22:49, GigabitEthernet2/0
O E1    30.37.0.0/22 [110/404] via 10.10.107.2, 00:22:49, GigabitEthernet4/0
                     [110/404] via 10.10.79.2, 00:22:49, GigabitEthernet2/0
```

Figura 49 - Tabela R7

```
     20.0.0.0/24 is subnetted, 3 subnets
O E2    20.0.1.0 [110/1200] via 10.10.107.2, 00:22:46, GigabitEthernet4/0
O E2    20.0.2.0 [110/1200] via 10.10.107.2, 00:22:46, GigabitEthernet4/0
O E2    20.0.3.0 [110/1200] via 10.10.107.2, 00:22:46, GigabitEthernet4/0
     40.0.0.0/30 is subnetted, 2 subnets
O E2    40.9.0.0 [110/400] via 10.10.107.2, 00:22:46, GigabitEthernet4/0
                 [110/400] via 10.10.79.2, 00:22:46, GigabitEthernet2/0
O E2    40.9.3.0 [110/1200] via 10.10.107.2, 00:22:46, GigabitEthernet4/0
     10.0.0.0/8 is variably subnetted, 22 subnets, 4 masks
O IA    10.12.12.0/30 [110/13] via 10.10.57.1, 00:22:46, GigabitEthernet3/0
O IA    10.12.13.0/30 [110/3] via 10.10.57.1, 00:22:46, GigabitEthernet3/0
O IA    10.12.24.0/30 [110/5] via 10.10.107.2, 00:22:46, GigabitEthernet4/0
                      [110/5] via 10.10.79.2, 00:22:46, GigabitEthernet2/0
O IA    10.11.35.0/30 [110/2] via 10.10.57.1, 00:22:47, GigabitEthernet3/0
O IA    10.11.36.0/30 [110/3] via 10.10.57.1, 00:22:47, GigabitEthernet3/0
O IA    10.11.45.0/30 [110/2] via 10.10.57.1, 00:22:47, GigabitEthernet3/0
O IA    10.11.46.0/30 [110/3] via 10.10.57.1, 00:22:47, GigabitEthernet3/0
C       10.10.57.0/30 is directly connected, GigabitEthernet3/0
O       10.10.68.0/30 [110/3] via 10.10.107.2, 00:22:47, GigabitEthernet4/0
                      [110/3] via 10.10.79.2, 00:22:47, GigabitEthernet2/0
O IA    10.13.74.0/27 [110/2] via 10.10.107.2, 00:22:47, GigabitEthernet4/0
                      [110/2] via 10.10.79.2, 00:22:47, GigabitEthernet2/0
C       10.10.79.0/30 is directly connected, GigabitEthernet2/0
O       10.10.89.0/30 [110/2] via 10.10.79.2, 00:22:47, GigabitEthernet2/0
C       10.10.107.0/30 is directly connected, GigabitEthernet4/0
O       10.10.108.0/30 [110/2] via 10.10.107.2, 00:22:47, GigabitEthernet4/0
O IA    10.13.119.0/30 [110/2] via 10.10.79.2, 00:22:47, GigabitEthernet2/0
O IA    10.12.119.0/30 [110/67] via 10.10.57.1, 00:22:47, GigabitEthernet3/0
O IA    10.13.121.0/30 [110/3] via 10.10.107.2, 00:22:47, GigabitEthernet4/0
                       [110/3] via 10.10.79.2, 00:22:47, GigabitEthernet2/0
O IA    10.13.120.0/30 [110/2] via 10.10.107.2, 00:22:48, GigabitEthernet4/0
O IA    10.12.219.0/30 [110/69] via 10.10.107.2, 00:22:48, GigabitEthernet4/0
                       [110/69] via 10.10.79.2, 00:22:48, GigabitEthernet2/0
C       10.255.7.7/32 is directly connected, Loopback0
O E2    10.255.4.4/32 [110/400] via 10.10.107.2, 00:22:48, GigabitEthernet4/0
                      [110/400] via 10.10.79.2, 00:22:48, GigabitEthernet2/0
O E2    10.255.12.0/24
          [110/1200] via 10.10.107.2, 00:22:48, GigabitEthernet4/0
     30.0.0.0/8 is variably subnetted, 5 subnets, 2 masks
O IA    30.39.1.0/30 [110/3] via 10.10.107.2, 00:22:48, GigabitEthernet4/0
                     [110/3] via 10.10.79.2, 00:22:48, GigabitEthernet2/0
O E1    30.38.0.0/22 [110/1202] via 10.10.107.2, 00:22:48, GigabitEthernet4/0
O IA    30.39.3.0/30 [110/77] via 10.10.57.1, 00:22:48, GigabitEthernet3/0
O IA    30.39.2.0/30 [110/3] via 10.10.107.2, 00:22:49, GigabitEthernet4/0
                     [110/3] via 10.10.79.2, 00:22:49, GigabitEthernet2/0
O E1    30.37.0.0/22 [110/404] via 10.10.107.2, 00:22:49, GigabitEthernet4/0
                     [110/404] via 10.10.79.2, 00:22:49, GigabitEthernet2/0
```

Figura 50 - Tabela R7

d)

Foi feito um ping múltiplo utilizando o comando tclsh para verificar a conectividade ao ISP por parte do cliente sul.

```
R18#tclsh
R18(tcl)#foreach address {
+>30.39.1.1
+>30.39.2.1
+>30.39.3.1
+>10.12.12.1
+>10.12.12.2
+>10.12.119.2
+>10.11.35.1
+>10.11.46.1
+>10.13.121.1
+>10.13.120.2
+>10.10.108.2
+>10.10.68.1
+>10.11.35.2
+>10.10.89.1
+>10.13.119.1
+>10.10.107.1
+>} {ping $address}
```

Figura 51 - Comando tclsh no router R18

Abaixo é apresentado o resultado desse ping múltiplo.

```
Type escape sequence to abort.
Sending 5, 100-byte ICMP Echos to 30.39.1.1, timeout is 2 seconds:
.!!!!
Success rate is 80 percent (4/5), round-trip min/avg/max = 60/194/564 ms
Type escape sequence to abort.
Sending 5, 100-byte ICMP Echos to 30.39.2.1, timeout is 2 seconds:
.!!!!
Success rate is 80 percent (4/5), round-trip min/avg/max = 64/180/504 ms
Type escape sequence to abort.
Sending 5, 100-byte ICMP Echos to 30.39.3.1, timeout is 2 seconds:
.!!!!
Success rate is 80 percent (4/5), round-trip min/avg/max = 144/277/668 ms
Type escape sequence to abort.
Sending 5, 100-byte ICMP Echos to 10.12.12.1, timeout is 2 seconds:
!!!!!
Success rate is 100 percent (5/5), round-trip min/avg/max = 148/166/208 ms
Type escape sequence to abort.
Sending 5, 100-byte ICMP Echos to 10.12.12.2, timeout is 2 seconds:
!!!!!
Success rate is 100 percent (5/5), round-trip min/avg/max = 124/144/152 ms
Type escape sequence to abort.
Sending 5, 100-byte ICMP Echos to 10.12.119.2, timeout is 2 seconds:
!!!!!
Success rate is 100 percent (5/5), round-trip min/avg/max = 128/188/264 ms
Type escape sequence to abort.
Sending 5, 100-byte ICMP Echos to 10.11.35.1, timeout is 2 seconds:
!!!!!
Success rate is 100 percent (5/5), round-trip min/avg/max = 120/138/152 ms
Type escape sequence to abort.
Sending 5, 100-byte ICMP Echos to 10.11.46.1, timeout is 2 seconds:
!!!!!
Success rate is 100 percent (5/5), round-trip min/avg/max = 120/150/164 ms
Type escape sequence to abort.
Sending 5, 100-byte ICMP Echos to 10.13.121.1, timeout is 2 seconds:
!!!!!
Success rate is 100 percent (5/5), round-trip min/avg/max = 60/67/88 ms
Type escape sequence to abort.
Sending 5, 100-byte ICMP Echos to 10.13.120.2, timeout is 2 seconds:
!!!!!
Success rate is 100 percent (5/5), round-trip min/avg/max = 28/53/60 ms
```

Figura 52 - Resultado tclsh

```
Type escape sequence to abort.
Sending 5, 100-byte ICMP Echos to 10.10.108.2, timeout is 2 seconds:
!!!!!
Success rate is 100 percent (5/5), round-trip min/avg/max = 60/79/96 ms
Type escape sequence to abort.
Sending 5, 100-byte ICMP Echos to 10.10.68.1, timeout is 2 seconds:
!!!!!
Success rate is 100 percent (5/5), round-trip min/avg/max = 88/100/120 ms
Type escape sequence to abort.
Sending 5, 100-byte ICMP Echos to 10.11.35.2, timeout is 2 seconds:
!!!!!
Success rate is 100 percent (5/5), round-trip min/avg/max = 88/100/120 ms
Type escape sequence to abort.
Sending 5, 100-byte ICMP Echos to 10.10.89.1, timeout is 2 seconds:
!!!!!
Success rate is 100 percent (5/5), round-trip min/avg/max = 88/89/92 ms
Type escape sequence to abort.
Sending 5, 100-byte ICMP Echos to 10.13.119.1, timeout is 2 seconds:
!!!!!
Success rate is 100 percent (5/5), round-trip min/avg/max = 60/72/92 ms
Type escape sequence to abort.
Sending 5, 100-byte ICMP Echos to 10.10.107.1, timeout is 2 seconds:
!!!!!
Success rate is 100 percent (5/5), round-trip min/avg/max = 92/104/124 ms
```

Figura 53 - Resultado tclsh

e)

Foram feitos 3 traces, um para cada Data Center a partir do PC7. No comando foi usada a opção -P para mudar o protocolo IP dos pacotes enviados pelo traceroute e a opção -m para abrangir mais hops.

```
PC7> trace 30.39.1.1 -P 6 -m 10
trace to 30.39.1.1, 10 hops max (TCP), press Ctrl+C to stop
 1   30.38.0.254   14.604 ms  4.544 ms  2.084 ms
 2   40.9.3.1   60.592 ms  45.483 ms  29.433 ms
 3   10.13.74.3   71.554 ms  55.849 ms  77.575 ms
 4   30.39.1.1   88.831 ms  92.520 ms  88.160 ms
```

Figura 54 - Traceroute para DC1

```
PC7> trace 30.39.2.1 -P 6 -m 10
trace to 30.39.2.1, 10 hops max (TCP), press Ctrl+C to stop
 1   30.38.0.254   2.507 ms  13.047 ms  10.588 ms
 2   40.9.3.1   31.832 ms  46.649 ms  16.008 ms
 3   30.39.2.1   39.622 ms  40.563 ms  59.915 ms
```

Figura 55 - Traceroute para DC2

```
PC7> trace 30.39.3.1 -P 6 -m 15
trace to 30.39.3.1, 15 hops max (TCP), press Ctrl+C to stop
 1   30.38.0.254   17.864 ms  27.386 ms  13.386 ms
 2   40.9.3.1   43.769 ms  30.254 ms  51.815 ms
 3   10.13.120.1   71.729 ms  83.256 ms  96.564 ms
 4   10.10.107.1   93.047 ms  91.338 ms  77.454 ms
 5   10.10.57.1   135.554 ms  145.230 ms  150.090 ms
 6   10.11.45.1   166.632 ms  167.714 ms  196.852 ms
 7   10.12.24.1   196.776 ms  222.258 ms  162.861 ms
 8   10.12.219.2   207.250 ms  191.123 ms  230.106 ms
 9   30.39.3.1   259.996 ms  226.850 ms  203.442 ms
```

Figura 56 - Traceroute para DC3

4. Configuração da rede da Tier 2 e ligação ao ISP

a)

O router ligado a um PC fica com o último endereço. Logo o router R14 ligado ao PC4 terá o endereço 8.8.255.254 e o PC4 terá o endereço 8.8.0.1 que irá simular o acesso à internet.

As configurações dos routers do ISP Tier 2 e do PC4 são as seguintes.

```
PC4> ip 8.8.0.1/16 8.8.255.254
Checking for duplicate address...
PC1 : 8.8.0.1 255.255.0.0 gateway 8.8.255.254

PC4> sh ip

NAME        : PC4[1]
IP/MASK     : 8.8.0.1/16
GATEWAY     : 8.8.255.254
DNS         :
MAC         : 00:50:79:66:68:03
LPORT       : 10206
RHOST:PORT  : 127.0.0.1:10207
MTU:        : 1500
```

Figura 57 - Configuração PC4

```
R15(config)#int g3/0
R15(config-if)#ip address 50.0.3.2 255.255.255.252
R15(config-if)#ex
R15(config)#int g4/0
R15(config-if)#ip address 50.0.2.2 255.255.255.252
R15(config-if)#ex
R15(config)#router ospf 2
R15(config-router)#router-id 15.15.15.15
R15(config-router)#passive-interface default
R15(config-router)#no passive-interface g3/0
R15(config-router)#no passive-interface g4/0
R15(config-router)#ex
R15(config)#router ospf 2
R15(config-router)#network 50.0.3.0 0.0.0.3 area 0
R15(config-router)#network 50.0.2.0 0.0.0.3 area 0
```

Figura 58 - Configuração R15

Como o ISP Tier 2 tem OSPF no seu core foi criado o processo 2 de OSPF para este ISP.

```
R13(config)#int g3/0
R13(config-if)#ip address 50.0.1.1 255.255.255.252
R13(config-if)#ex
R13(config)#int g4/0
R13(config-if)#ip address 50.0.2.1 255.255.255.252
R13(config-if)#ex
R13(config)#int g5/0
R13(config-if)#ip address 50.0.0.2 255.255.255.252
```

```
R13(config)#router ospf 2
R13(config-router)#router-id 13.13.13.13
R13(config-router)#passive-interface default
R13(config-router)#no passive-interface g3/0
R13(config-router)#no passive-interface g4/0
R13(config-router)#no passive-interface g5/0
```

```
R13(config-router)#network 50.0.0.0 0.0.3.255 area 0
R13(config-router)#network 50.0.1.0 0.0.0.3 area 0
R13(config-router)#no network 50.0.0.0 0.0.3.255 area 0
R13(config-router)#network 50.0.0.0 0.0.0.3 area 0
R13(config-router)#network 50.0.2.0 0.0.0.3 area 0
```

Figura 60 - Configuração R13

```
R14(config)#router ospf 2
R14(config-router)#passive-interface default
R14(config-router)#no passive-interface g2/0
R14(config-router)#no passive-interface g3/0
R14(config-router)#no passive-interface f0/0
R14(config-router)#ex
R14(config)#router ospf 2
R14(config-router)#network 50.0.1.0 0.0.0.3 area 0
R14(config-router)#network 50.0.1.0 0.0.0.3 area 0
*Jan  3 13:20:41.423: %OSPF-5-ADJCHG: Process 2, Nb
R14(config-router)#network 50.0.3.0 0.0.0.3 area 0
R14(config-router)#network 8.8.255.0 0.0.255.255
```

```
R14(config)#int f0/0
R14(config-if)#ip address 8.8.255.254 255.255.0.0
R14(config-if)#ex
R14(config)#int g2/0
R14(config-if)#ip address 50.0.1.2 255.255.255.252
R14(config-if)#ex
R14(config)#int g3/0
R14(config-if)#ip address 50.0.3.1 255.255.255.252
```

Figura 59 - Configuração R14

b)

A conexão entre os ISPs vai ser realizada através de encaminhamento estático.

Foram criadas algumas rotas estáticas para partilha com o comando **ip route** e o comando **redistribute static** no processo ospf.

```
ip route 10.10.0.0 255.255.255.252 50.0.0.2
ip route 50.0.0.0 255.255.255.252 50.0.0.2
```

Também foi necessário redistribuir rotas de cada processo ospf **com redistribute ospf [process id] subnets**, sendo assim possível o Tier 2 ter acesso a todas as rotas e o ISP ter acesso ao Tier 2.

c)

Para fazer um ping múltiplo foi necessário utilizar o comando tclsh.

```
R14(tcl)#foreach address {
+>30.39.1.1
+>30.39.2.1
+>30.39.3.1
+>10.12.12.1
+>10.12.12.2
+>10.12.119.2
+>10.11.35.1
+>10.11.46.1
+>10.13.121.1
+>10.13.121.1
+>10.13.120.2
+>10.10.108.2
+>10.10.68.1
+>10.11.35.2
+>10.10.89.1
+>10.13.119.1
+>10.10.107.1
+>30.38.0.254
+>30.37.0.254
+>} { ping $address}
```

Figura 61 - Comando tclsh

```
Success rate is 100 percent (5/5), round-trip min/avg/max = 176/203/228 ms
Type escape sequence to abort.
Sending 5, 100-byte ICMP Echos to 10.10.108.2, timeout is 2 seconds:
!!!!!
Success rate is 100 percent (5/5), round-trip min/avg/max = 104/140/172 ms
Type escape sequence to abort.
Sending 5, 100-byte ICMP Echos to 10.10.68.1, timeout is 2 seconds:
!!!!!
Success rate is 100 percent (5/5), round-trip min/avg/max = 124/174/212 ms
Type escape sequence to abort.
Sending 5, 100-byte ICMP Echos to 10.11.35.2, timeout is 2 seconds:
!!!!!
Success rate is 100 percent (5/5), round-trip min/avg/max = 48/77/116 ms
Type escape sequence to abort.
Sending 5, 100-byte ICMP Echos to 10.10.89.1, timeout is 2 seconds:
!!!!!
Success rate is 100 percent (5/5), round-trip min/avg/max = 136/204/320 ms
Type escape sequence to abort.
Sending 5, 100-byte ICMP Echos to 10.13.119.1, timeout is 2 seconds:
!!!!!
Success rate is 100 percent (5/5), round-trip min/avg/max = 80/128/164 ms
Type escape sequence to abort.
Sending 5, 100-byte ICMP Echos to 10.10.107.1, timeout is 2 seconds:
!!!!!
Success rate is 100 percent (5/5), round-trip min/avg/max = 40/108/160 ms
Type escape sequence to abort.
Sending 5, 100-byte ICMP Echos to 30.38.0.254, timeout is 2 seconds:
!!!!!
Success rate is 100 percent (5/5), round-trip min/avg/max = 84/189/312 ms
Type escape sequence to abort.
Sending 5, 100-byte ICMP Echos to 30.37.0.254, timeout is 2 seconds:
!!!!!
Success rate is 100 percent (5/5), round-trip min/avg/max = 124/144/196 ms
```

Figura 62 - Parte do resultado

d)

Abaixo é apresentado o resultado dos vários traceroutes para os Data Centers.

```
PC4> trace 30.39.1.1 -P 6
trace to 30.39.1.1, 8 hops max (TCP), press Ctrl+C to stop
 1   8.8.255.254   6.833 ms  11.992 ms  11.071 ms
 2   50.0.1.1   23.507 ms  20.787 ms  21.743 ms
 3   50.0.0.1   89.107 ms  82.542 ms  49.405 ms
 4   10.10.57.2   86.288 ms  113.237 ms  78.140 ms
 5   10.10.107.2   142.094 ms  72.225 ms  87.311 ms
 6   10.13.74.3   130.491 ms  94.536 ms  115.652 ms
 7   30.39.1.1   129.962 ms  113.120 ms  117.154 ms

PC4> trace 30.39.2.1 -P 6
trace to 30.39.2.1, 8 hops max (TCP), press Ctrl+C to stop
 1   8.8.255.254   63.588 ms  2.221 ms  28.290 ms
 2   50.0.1.1   48.058 ms  71.792 ms  44.875 ms
 3   50.0.0.1   73.961 ms  68.233 ms  76.430 ms
 4   10.10.57.2   136.654 ms  117.578 ms  133.048 ms
 5   10.10.107.2   136.948 ms  199.512 ms  112.409 ms
 6   10.13.74.4   183.512 ms  255.590 ms  191.355 ms
 7     *  *  *
 8   30.39.2.1   256.319 ms  4294966.903 ms  4294962.500 ms

PC4> trace 30.39.3.1 -P 6
trace to 30.39.3.1, 8 hops max (TCP), press Ctrl+C to stop
 1   8.8.255.254   12.059 ms  12.420 ms  4.746 ms
 2   50.0.1.1   49.284 ms  67.883 ms  52.283 ms
 3   50.0.0.1   135.346 ms  91.152 ms  95.582 ms
 4   10.11.35.1   138.488 ms  117.875 ms  84.798 ms
 5   10.12.13.1   112.741 ms  102.666 ms  152.222 ms
 6   10.12.119.2   222.755 ms  166.198 ms  230.929 ms
 7     *  *  *
 8   30.39.3.1   209.678 ms  3.257 ms  46.270 ms
```

Figura 63 - Traces pelo PC4

5. Configuração da rede do Cliente centro e ligação ao ISP

a)

Os routers que têm que criar a ligação são os routers R6, R10 e R17. Abaixo são apresentadas as configurações.

```
PC6> ip 30.36.0.1/24 30.36.0.254
Checking for duplicate address...
PC1 : 30.36.0.1 255.255.255.0 gateway 30.36.0.254

PC6> sh p
Invalid arguments

PC6> sh ip

NAME        : PC6[1]
IP/MASK     : 30.36.0.1/24
GATEWAY     : 30.36.0.254
DNS         :
MAC         : 00:50:79:66:68:05
LPORT       : 10210
RHOST:PORT  : 127.0.0.1:10211
MTU:        : 1500
```

Figura 64 - Configuração PC6

A configuração do router R10 foi feita da seguinte maneira.

```
R10(config)#router rip
R10(config-router)#version 2
R10(config-router)#redistribute ospf 1 metric 10
R10(config-router)#network 30.0.0.0
R10(config-router)#network 40.0.0.0
R10(config-router)#ex
R10(config)#router ospf 1
R10(config-router)#redistribute rip metric 10000 metric-type 1 subnets
```

```
router ospf 1
 router-id 10.10.10.10
 log-adjacency-changes
 area 3 virtual-link 12.12.12.12
 redistribute rip metric 10000 metric-type 1 subnets
 passive-interface default
 no passive-interface FastEthernet0/0
 no passive-interface FastEthernet1/0
 no passive-interface GigabitEthernet2/0
 no passive-interface GigabitEthernet3/0
 no passive-interface GigabitEthernet4/0
 network 10.10.107.0 0.0.0.3 area 0
 network 10.10.108.0 0.0.0.3 area 0
 network 10.13.74.0 0.0.0.31 area 3
 network 10.13.120.0 0.0.0.3 area 3
```

Figura 65 - Configuração R10 final

O router R6 foi configurado com os seguintes comandos.

```
R6(config)#router rip
R6(config-router)#version 2
R6(config-router)#redistribute ospf 1 metric 6
R6(config-router)#network 30.0.0.0
R6(config-router)#network 40.0.0.0
R6(config-router)#ex
R6(config)#router ospf 1
R6(config-router)#redistribute rip metric 6000 metric-type 1 subnets
```

Dando assim a seguinte configuração.

```
router ospf 1
 router-id 6.6.6.6
 log-adjacency-changes
 area 1 virtual-link 4.4.4.4
 redistribute connected metric 6000 subnets
 redistribute rip metric 6000 metric-type 1 subnets
 passive-interface default
 no passive-interface FastEthernet0/0
 no passive-interface GigabitEthernet2/0
 no passive-interface GigabitEthernet3/0
 no passive-interface GigabitEthernet4/0
 network 10.10.68.0 0.0.0.3 area 0
 network 10.11.36.0 0.0.0.3 area 1
 network 10.11.46.0 0.0.0.3 area 1
 default-information originate
```

Figura 66 – Configuração R6

b)

1	2021-01-04 03:54:40,488205	ca:0c:09:e0:00:00	ca:0c:09:e0:00:00	LOOP	60	Reply
2	2021-01-04 03:54:47,793994	40.9.1.2	224.0.0.9	RIPv2	206	Response
3	2021-01-04 03:54:53,862969	ca:0c:09:e0:00:00	ca:0c:09:e0:00:00	LOOP	60	Reply
4	2021-01-04 03:55:11,144057	ca:0c:09:e0:00:00	ca:0c:09:e0:00:00	LOOP	60	Reply
5	2021-01-04 03:55:12,105867	ca:0c:09:e0:00:00	CDP/VTP/DTP/PAgP/UD…	CDP	340	Device ID: R17 Port ID: FastEthern…
6	2021-01-04 03:55:28,388949	ca:0c:09:e0:00:00	ca:0c:09:e0:00:00	LOOP	60	Reply
7	2021-01-04 03:55:30,774230	40.9.1.2	224.0.0.9	RIPv2	206	Response
8	2021-01-04 03:55:46,017490	ca:0c:09:e0:00:00	ca:0c:09:e0:00:00	LOOP	60	Reply
9	2021-01-04 03:56:02,826959	ca:0c:09:e0:00:00	ca:0c:09:e0:00:00	LOOP	60	Reply
10	2021-01-04 03:56:20,691760	ca:0c:09:e0:00:00	ca:0c:09:e0:00:00	LOOP	60	Reply
11	2021-01-04 03:56:22,427922	40.9.1.2	224.0.0.9	RIPv2	206	Response
12	2021-01-04 03:56:32,584773	ca:0c:09:e0:00:00	ca:0c:09:e0:00:00	LOOP	60	Reply
13	2021-01-04 03:56:48,267752	ca:0c:09:e0:00:00	ca:0c:09:e0:00:00	LOOP	60	Reply
14	2021-01-04 03:56:48,883739	ca:0c:09:e0:00:00	CDP/VTP/DTP/PAgP/UD…	CDP	340	Device ID: R17 Port ID: FastEthern…
15	2021-01-04 03:56:59,156557	40.9.1.2	224.0.0.9	RIPv2	206	Response
16	2021-01-04 03:57:02,162805	ca:0c:09:e0:00:00	ca:0c:09:e0:00:00	LOOP	60	Reply
17	2021-01-04 03:57:18,223005	ca:0c:09:e0:00:00	ca:0c:09:e0:00:00	LOOP	60	Reply
18	2021-01-04 03:57:35,358985	ca:0c:09:e0:00:00	ca:0c:09:e0:00:00	LOOP	60	Reply
19	2021-01-04 03:57:44,710030	40.9.1.2	224.0.0.9	RIPv2	206	Response
20	2021-01-04 03:57:53,367896	ca:0c:09:e0:00:00	ca:0c:09:e0:00:00	LOOP	60	Reply
21	2021-01-04 03:58:10,598206	ca:0c:09:e0:00:00	ca:0c:09:e0:00:00	LOOP	60	Reply
22	2021-01-04 03:58:28,171892	ca:0c:09:e0:00:00	ca:0c:09:e0:00:00	LOOP	60	Reply

Figura 67 – Wireshark entre R6/R17

c)

A comunicação faz sempre pelo router R10. No traceroute apresenta o caminho entre R6 – R8 – R10 – R17.

d)

Para interromper a comunicação do router R10 com o router R17 suspende-se no gns3 o link entre estas.

6. Otimização das tabelas de encaminhamento.

a)

A opção correta a escolher para a área 2 é Totally Not So Stubby pois faz uma ligação ao exterior e assim necessita de reter os LSAs tipo 5 que serão convertidos para tipo 7. Para configurar a área 2 temos que efetuar o comando **area 2 nssa no-summary** em todos os routers da área 2.

b)

A opção correta a escolher para a área 3 é Stub pois é uma zona remota que não necessita de saber todos os prefixos do ISP e não faz ligações ao exterior. Para realizar esta mudança temos que executar o comando **area 3 stub** no ASBR que neste caso será R12.

Conclusão

- Com este trabalho pudemos colocar em prática os conhecimentos e aprendizagens dados na cadeira de Redes de Internet até ao momento do trabalho, sobre o protocolo de roteamento OSPF.

Bibliografia

- Documentos de apoio da unidade curricular e material fornecido pelo docente e regente da cadeira.
- https://community.cisco.com/